october, 1960

nlgi spokesman

journal of the national lubricating grease institute

28th annual meeting
national lubricating grease institute
october 30 - november 2, 1960
edgewater beach hotel, chicago

Better Greases Through BAROID RESEARCH

BARAGEL 24* provides greater stability in greases made from non-petroleum oils

BARAGEL 24, a non-soap grease-gelling agent, gives greater stability to greases made from such non-petroleum oils as polyalkylene glycols, di-2-ethylhexyl sebacate, di-2-ethylhexyl adipate and castor oil. The development of BARAGEL 24 is another result of Baroid Chemicals' research.

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Volume XXIV October, 1960 Number 7

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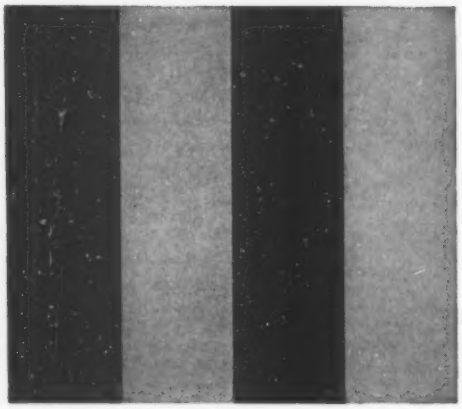
THE COVER

OUR cover, the design for the 28th NLGI Annual Meeting, might well be explained in the words of one member . . . "The industry doesn't want a larger slice of the pie . . . we want to work for a bigger pie." Hence, "Expand Demand" with a low bow to Milburn Petty and Keith Fanshier of the *Oil Daily*, who allowed their slogan to be borrowed and condensed. For the aggressive marketer who comes to Chicago October 30-November 2, there will be a host of ideas on how to accomplish this purpose. A full day of scheduling for Technical men has been added. Page 255.

The NLGI SPOKESMAN is indexed by Industrial Arts Index and Chemical Abstracts. Microfilm copies are available through University Microfilm, Ann Arbor, Mich. The NLGI assumes no responsibility for the statements and opinions advanced by contributors to its publications. Views expressed in the editorials are those of the editors and do not necessarily represent the official position of the NLGI. Copyright 1960. National Lubricating Grease Institute.



NLGI PRESIDENT'S PAGE

By H. A. MAYOR, JR., *President*

Recent Board Action

In direct competition with Hurricane "Donna," 17 out of your 21 Board of Director members met for a full day session in New York City Monday, September 12th. It was an interesting, important meeting during which your Board faced and wrestled with an extremely heavy agenda. Here's a thumbnail résumé of certain of the items that came before the Board for attention and action which should be of interest to our general membership—

After full consideration, the Board voted against the acceptance of Battelle Memorial Institute's proposed study of current and future grease markets. The Board agreed that current market trends are disturbing and that our industry should continue to explore every possible method to counteract them. Further Board work will continue in this direction.

The proposed IOCA merger was abandoned and the temporary NLGI assistance to this group will terminate by December, 1960.

The energetic work of the Chassis Lube Committee, headed by J. W. Lane, was reviewed in detail and solid progress continued towards the development of a hard-hitting report with recommendations for presentation to the entire membership at our annual meeting. There's good, substantial work being done in this area and you will be hearing more about it later.

The report of our ambitious, hard-working Vice-President and Program Chairman, Frank Hart, covering the largest, most promptly completed program in NLGI history was accepted with a rousing round of applause. It was an exceptionally good report covering a meeting you'll not want to miss.

I'm looking forward to seeing you in Chicago at the Edgewater Beach Hotel for that big annual meeting week starting October 30th—see you there!

H. A. MAYOR, JR.
President

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Here's why:
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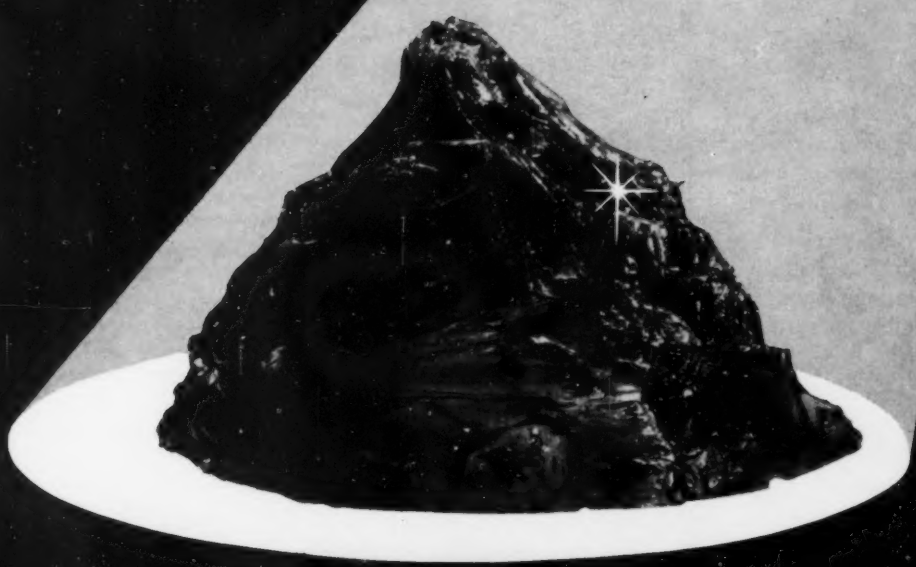

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Future Meetings

OCTOBER, 1960

9-13 ASTM, Committee D-2 meeting, Mayflower Hotel, Washington, D. C.

10-12 API Division of Marketing, marketing research committee, Baker Hotel, Dallas.

17-19 ASME – ASLE Lubrication Conference, Statler Hilton Hotel, Boston.

OCT. 30 - NOV. 2 NLGI Annual Meeting, Edgewater Beach Hotel, Chicago

NOVEMBER, 1960

2 Packaging Institute, petroleum packaging committee meeting, headquarters undecided, New York.

3-4 SAE National Fuels and Lubricants Meeting, Mayo Hotel, Tulsa, Okla.

14-16 API 40th Annual Meeting, Conrad Hilton, Palmer House and Congress Hotels, Chicago.

15-17 Air Force–Navy–Industry Propulsion Systems Lubricants Conference (unclassified), Hilton Hotel, San Antonio, Tex.

27-Dec. 2 ASME Annual Meeting, Statler Hilton Hotel, New York.

JANUARY, 1961

9-13 Society of Automotive Engineers Annual Meeting, Cobo Hall and Convention Arena, Detroit.

FEBRUARY, 1961

5-10 ASTM Committee D-2 meeting, Benjamin Franklin Hotel, Philadelphia, Pa.

MAY, 1961

16-19 API Division of Marketing, Midyear Meeting, Americana Hotel, Miami Beach, Fla.

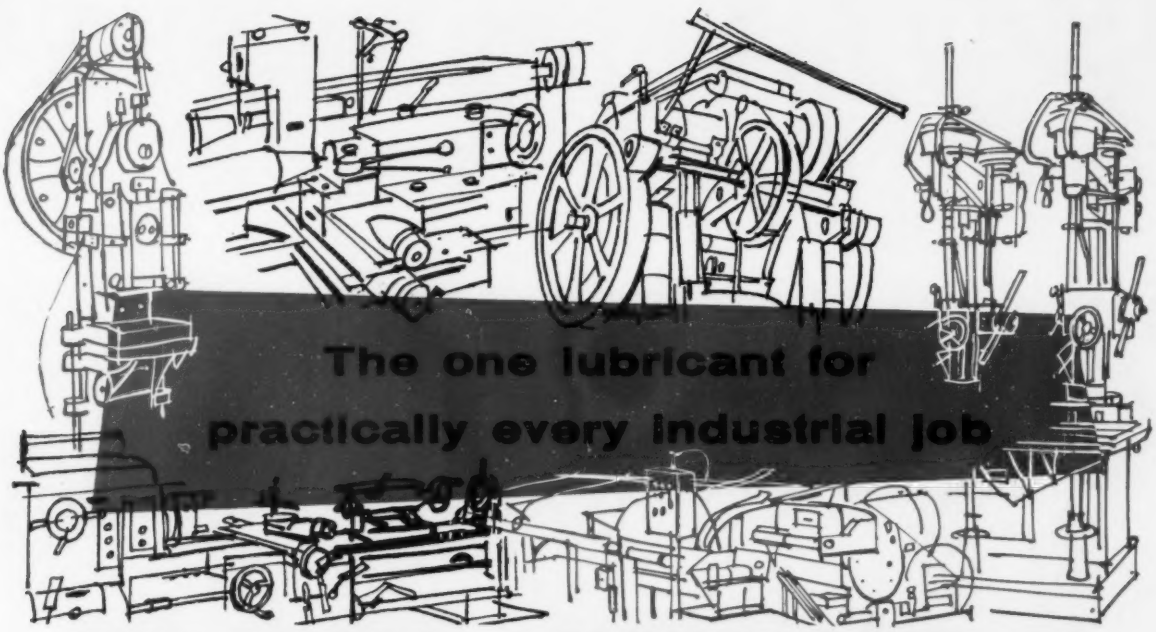
OCT. 29 - NOV. 1, 1961 NLGI Annual Meeting, Rice Hotel, Houston, Tex.

ADVANTAGES
of membership in the
National Lubricating Grease Institute

Some of the membership advantages are listed below:

- The NLGI represents over 95 per cent of the lubricating grease industry with members in this country and overseas.
- NLGI has a Technical Committee of 154 members which is divided into nine sub-committees working constantly on industry problems.
- The NLGI SPOKESMAN, a monthly technical journal, is mailed free of charge to key personnel within a member firm. If extra copies of the magazine are needed, they may be purchased at half the regular subscription price.
- The Institute works in close cooperation with affiliated groups including SAE, ASTM, ASA, ASLE, ASME, SAE-Cimtc and IOCA on problems and accomplishments in the lubricating field.
- The main objectives of the National Lubricating Grease Institute are for the development of better lubricating greases for the consumer and better grease lubrication engineering service to industry.

If your firm is interested in becoming affiliated with NLGI, the national office will be happy to furnish further information concerning the organization. Just as 1959 was a banner year for NLGI accomplishments 1960 promises to be even better with more scope and more member advantages.



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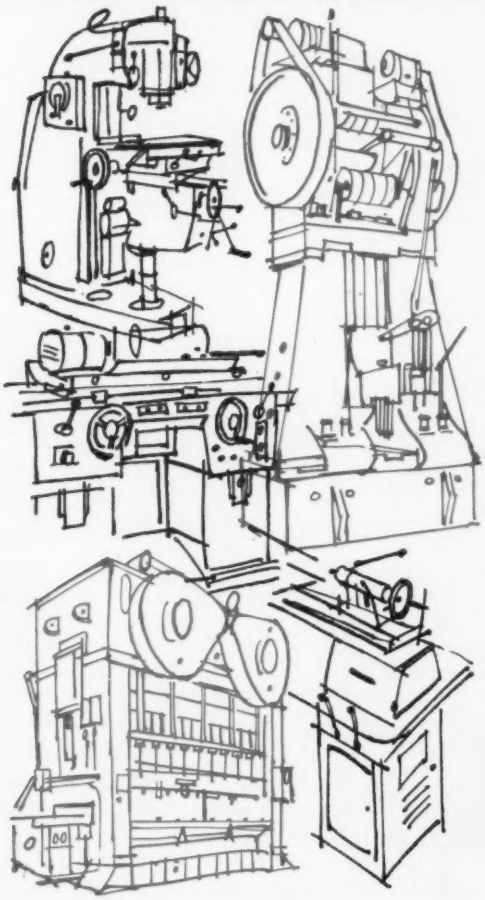

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News About NLGI

M. F. A. Oil Co. Joins NLGI

M. F. A. Oil company of Columbia, Missouri, has joined NLGI as a Marketing member. Stuart L. Spradling, director of research, will serve as both Company and Technical representative to the Institute. A warm welcome is extended to this new member from its many friends in NLGI.

Change Representatives

Ampol Petroleum of Balmain, New South Wales, Australia, has appointed M. E. Brownell as Company representative to NLGI for this Marketing member firm.

C. A. Nacional de Grasas Lubricantes of Caracas, Venezuela, has appointed D. A. Smith, consulting engineer, as Technical representative of this Active member. Mr. Smith will represent the company in the United States. Dr. Ladislao Szikora is Company representative, in Venezuela.

Farval Division of Eaton Manufacturing company in Cleveland, an NLGI Associate, has named E. J. Gesdorf as Company representative.

Valvoline Oil division of Ashland Oil and Refining company at Ashland, Kentucky, has named R. L. Sailer as both Company and Technical representative to NLGI, replacing D. A. Smith, retired, from this Marketing member firm.

Report of Petroleum Packaging Committee Meeting, June, 1960

Mr. H. E. Griffith, vice-president of Thatcher Glass Manufacturing company's plastic container division, gave a very interesting review of Plastics in Convenience Packaging for the Petroleum Industry. He advises not putting a plastic package to work first as a direct replacement for present containers. Rather to use plastic packages in developing sales improvement of merchandise related to the automobile and home. The service station of the future will be designed to get customers out of their cars, and into a waiting room which contains well displayed merchandise in plastic containers. Many possible convenience applications of plastics were discussed and samples displayed.

Gap-Flap Cases — approval has been given by ICC for carload, LCL and truckload shipments for the use of up to 3" top and 2" bottom gap but momentarily LTL approval is expected.

Shell Oil in California has made application for 175 *lb. test* 24/1 *quart cases* while another company in California is already using this type of case within the state.

Experimental work on 28/1 *quart cases* diagonally packed in double tier appeared too weak.

A German company is offering a polypropylene foil, either in 100 lb. rolls or in made-up units, *for asphalt packaging*. When melting the ready made block at above 300 Degrees F., the foil melts into the asphalt without injuring its quality.

Following the recommendation of the *Metal Drums and Pails Subcommittee*, the Petroleum Packaging committee approved formation of a new Export Shipping Subcommittee to handle developments in connection with ocean shipping charges.

To support a proposal to amend freight tariffs so that the 55 gallon FRH 20/18 gauge drum can be used for non - hazardous liquids, the Chemical Packages committee of MCA asks the cooperation of all interested companies in compiling all the data that has been or will be obtained from test shipments.

Test rail shipments of 120-lb., 24-gauge FRH drums are under way. Several companies report satisfactory test shipments of 5-gallon LC Pails with lowered top bead and new design handles. Also further shipments are being made of 35-lb., 29-gauge pails. It was reported that 29 - gauge pails are substantially cheaper than 28-gauge pails.

Embossing of the letter "O" on the top of 55-gallon drums is no longer included in the new ASA Standards. MPSA is reported to be starting proceedings to change Federal specifications accordingly.

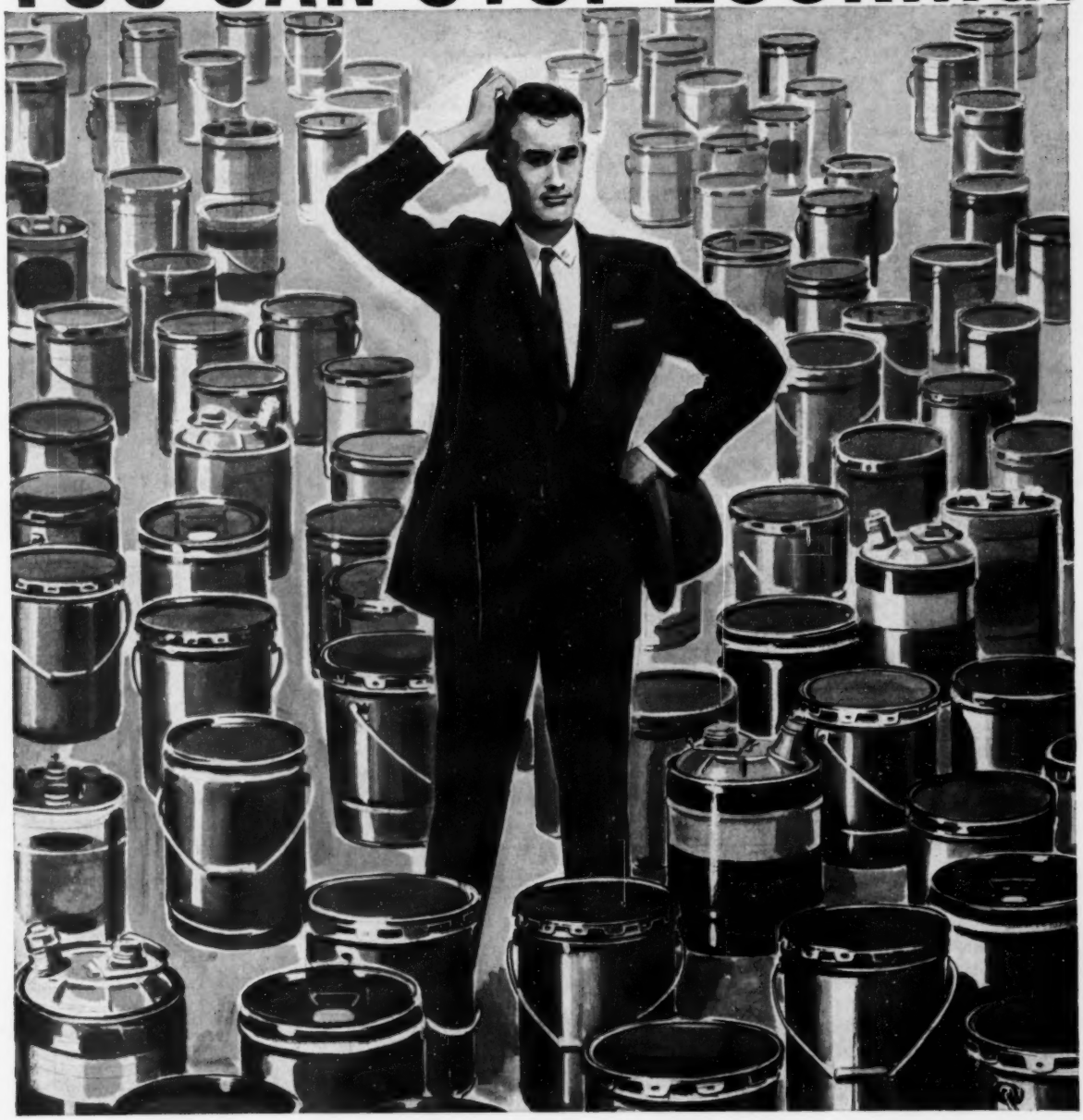
Reconditioned, or even new drum plugs may not be as clean as is desirable. The Subcommittee will work with manufacturers and reconditioners to achieve the desired degree of cleanliness.

The report of the *Palletization & Wax* Subcommittee gives detailed data on packaging practices for the one-ton palletized unit. Comments indicate cost savings by using ¾ x.015 gauge straps and advantages are claimed for the use of rayon cord Avistrap instead of steel strapping.

The *Traffic* subcommittee reports test shipments data are being accumulated on grease and oil in 24 gauge 120 lb. drums. Solid grease

Continued on page 248

YOU CAN STOP LOOKING!



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NLGI News

Continued from page 246

shipments in 400 pound 20/18 gauge open head drums, and in 29 gauge 5-gallon drums are authorized.

Minimum specifications of shipping cases (both inner and outer) for grease cartridges have been reduced. No classification committee action has yet been taken on use of 175 lb. test fibreboard for lubricating oil cases (present requirement is 200 lb. test).

ICC ruling is expected on whether tank or common carrier truckers will haul collapsible rubber or plastic bags such as sealdtanks.

Standardization of motor truck dimensions and weights awaits completion of AASHO road tests. Tests and reports may be completed in 1961 when the vehicle fleet will have accumulated 15 million miles and one million load applications.

The *Small Metal Packages* Subcommittee states that the one and five pound grease cans have been taken off ASA standards because there is nothing critical for dimensions. Many companies are considering replacing the five-quart can with a four-quart container.

Page 60.3.1 of the ASA notebook gives standard dimension for 14 oz. grease cartridges.

The *Standards* subcommittee expects publication of new ASA standards for four additional drums, as follows: 57 gallon FRH; 30 gallon Rule 40 FRH; 30 gallon ICC-17H FRH; 16 gallon FRH bolted ring cover.

The next Petroleum Packaging committee meeting will be held at the Statler-Hilton in New York City November 2, 1960.

SERVICE AIDS

Send Orders to: National Lubricating Grease Institute, 4638 Nichols Pkwy., Kansas City 12, Mo.

NLGI GLOSSARY—A four-page booklet containing definitions of terms relating to the lubricating grease industry. Usable by marketing as well as technical people. Fifteen cents per copy (NLGI member price) and twenty-five cents (non-member).

BALL JOINT BOOKLET — "Recommended Practices for Lubricating Passenger Car Ball Joint Front Suspensions." The latest aid in application, created by experts in the field and designed for use in the station. Twelve pages, easy to read, with large illustrations throughout. Twenty-five cents a copy with quantity discounts—company imprint arranged.

NLGI MOVIE — "Grease, the Magic Film," a 16-mm sound movie in color running about 25 minutes, now released. First print $300, second and subsequent orders $200 each (non-members add $100 to each price bracket).

WHEEL BEARING MANUAL — "Recommended Practices for Lubricating Automotive Front Wheel Bearings." More than 170,000 copies of this booklet have been distributed throughout the world. Now in its sixth printing. Sixteen pages, with more than 40 illustrations. Twenty-five cents a copy, with quantity discounts — company imprint arranged.

BONER'S BOOK—Manufacture and Application of Lubricating Greases, by C. J. Boner. This giant, 982-page book with 23 chapters dealing with every phase of lubricating greases is a must for everyone who uses, manufactures or sells grease lubricants. A great deal of practical value. $18.50, prepaid.

REPRINTS — From the NLGI SPOKESMAN are available at low cost. Page forms are left standing for three months, company imprint or advertising arranged.

VOLUME XXI—Bound volume of the NLGI SPOKESMAN from April, 1957 through March, 1958. Contains 34 articles and features dealing with lubricating greases and gear lubricants . . . $7.50 (NLGI member price) and $10.50 (non-member) plus postage.

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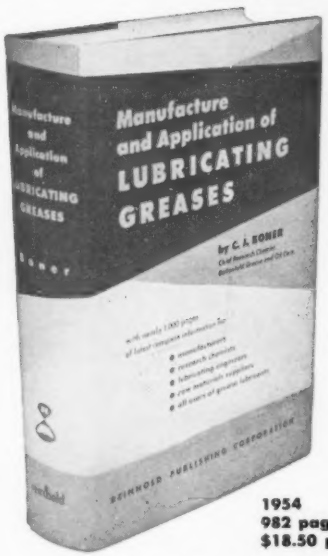
by C. J. Boner

Chief Research Chemist
Battenfeld Grease and Oil Corp.



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12 Lead Soap Lubricating Greases
13 Strontium Base Lubricating Greases
14 Miscellaneous Metal Soaps as Components of Lubricating Greases
15 Mixed Base Lubricating Greases
16 Complex Soap Lubricating Greases
17 Non-Soap Thickeners for Lubricating Fluids
18 Fillers in Lubricating Greases and Solid Lubricants
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Here in one giant volume . . . the most c mplete storehouse of information ever published on the composition, properties and uses of lubricating greases!

The book begins by describing in detail the structure and theory of lubricating greases. Then follow chapters on the various raw materials, processes and manufacturing equipment. Lubricants containing specific thickeners, including such recent developments as lithium soaps, complex soaps and non-soap gelling agents, receive special attention.

Of major interest is the large section on present uses and future trends of lubricating grease products. Here you'll find the complete details of when, where, and how to apply a specific lubricant for any given purpose.

Everyone concerned with the preparation or use of grease lubricants will find Boner's book of enormous practical value. Manufacturers and lubricating engineers will find here a complete breakdown of the effects of each ingredient of treatment upon the characteristics of the final product, and a full explanation of the physical and chemical methods used in measuring these characteristics. Suppliers of fats, oils, additives, thickeners and other raw materials will gain new ideas for future product research and development. In addition, users of grease products will learn the properties of available lubricants and the major purposes that each fulfills.

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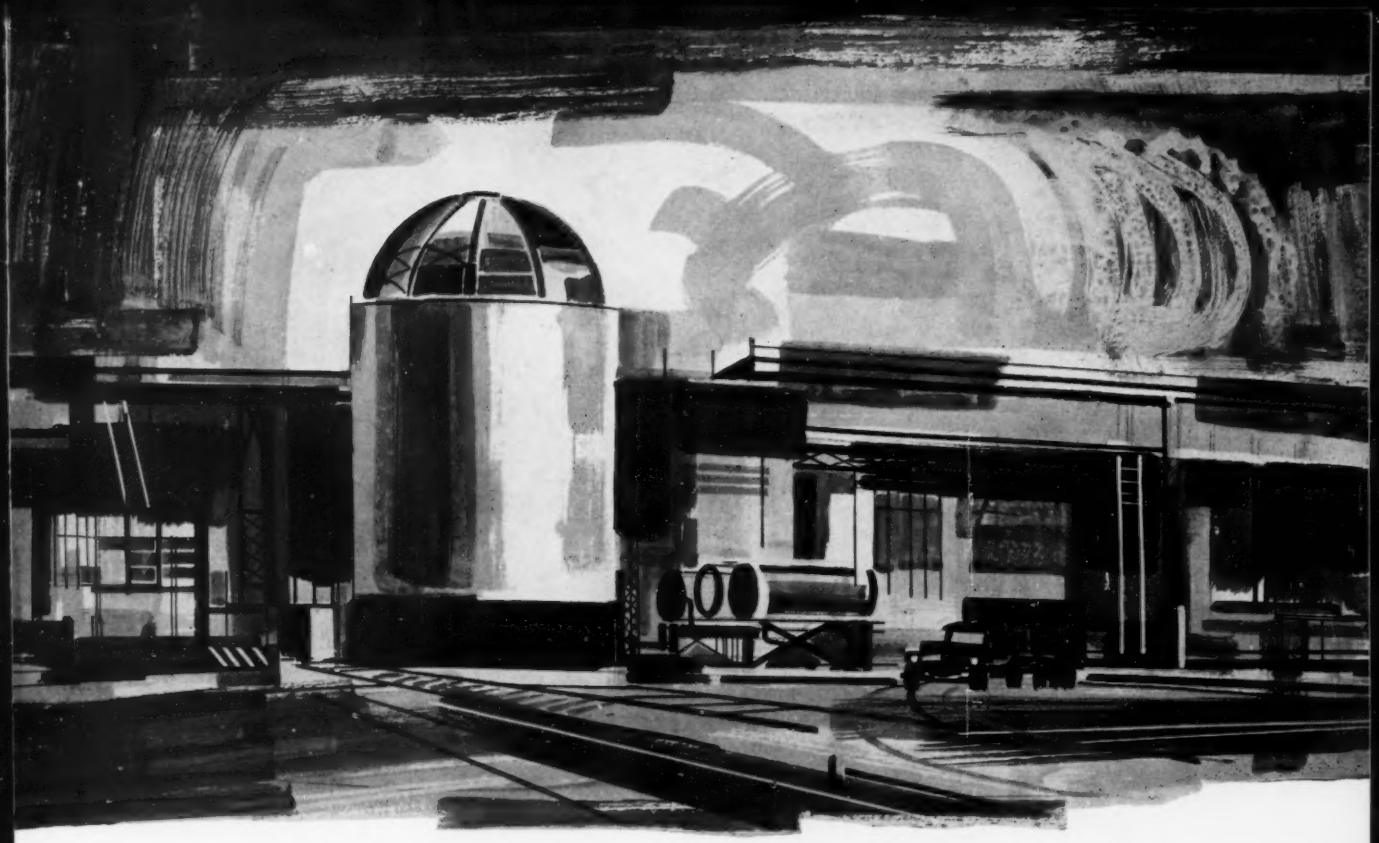
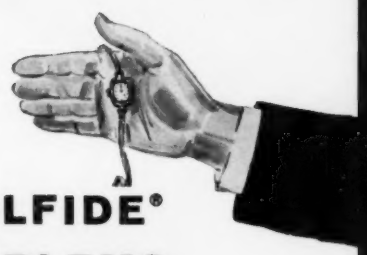


From a nuclear reactor . . .

to a delicate watch . . .



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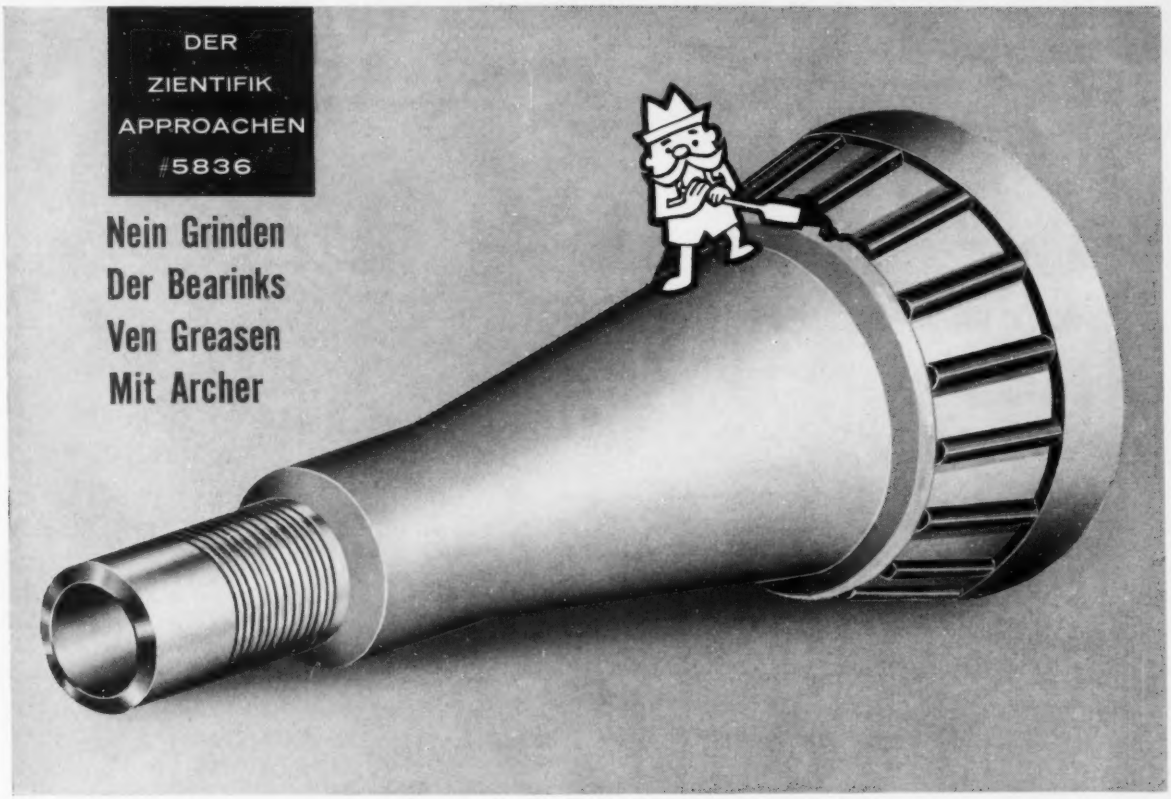
Volumes I through XXIII may be purchased from University Microfilms, 313 North First Street, Ann Arbor, Michigan.



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28th
NLGI Annual Meeting

Edgewater Beach Hotel
Chicago, Ill.

October 30—November 2, 1960

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1960 Annual Meeting Papers and Authors

Guzzo

Keynote Address

By C. J. GUZZO, Gulf Oil Corporation

C. J. Guzzo is a senior vice-president of Gulf Oil Corp. He has been with the Gulf organization continuously since 1914 when he was employed as a clerk in the company's bulk plant at Alexandria, La. He served as a company agent and as state manager for Tennessee, before being transferred to the New Orleans division office in 1934 as assistant division manager in charge of automotive sales. In 1949 he was promoted to general manager of the division. He remained in this position until he was elected vice-president in charge of domestic marketing in 1954. He has been a senior vice-president since June, 1959. A member of the American Petroleum Institute, Mr. Guzzo is vice-president of the API marketing division.

Johnson

Selling the Lubricating Grease Market

By C. L. JOHNSON, Jesco Lubricants Co.

C. L. Johnson received a BS degree from the University of Oklahoma in 1917. He started his business career with Marland Refining Co., Ponca City, Okla. In 1929 he became associated with Jesco Lubricants Co., North Kansas City, Mo., of which he is now president. Secretary of NLGI, he has served on the board of directors since 1953. Mr. Johnson is also a member of ASTM, ASLE, SAE and API.

Abstract

American business, lulled into a state of complacency during the early post-war period, and tended to forget the time-proven truth that the "consumer is King".

What is needed is a more comprehensive approach than mere "high-pressure salesmanship". This is the task of marketing to give the necessary insights into a complex picture.

First, there is the problem of finding out what the purchaser wants.

Second, there is the task of informing the consumer of products that might better serve his needs.

Third, it is necessary to increase efficiency and reduce costs of distribution.

Marketing is the process of getting goods or services out of the hands of the producer into the hands of the consumer. Wholesaling and retailing; buying, selling, and advertising; collection and accounting; storage and delivery—all are but parts of the whole.

Market development is the application of scientific principles to observational, experimentational, historical, survey methods for a consumer market.

Marketing development is the tool by which management is supplied the necessary information which imagination and ingenuity converts into a stronger competitive position.

Market development may not only help management in the development of increased sales, but may provide better means to reach the potential buyers.

There are three main categories: Markets, Products and Distribution methods.

Kasten

Why Wire Rope Lubricants Are Special Compounds

By R. O. KASTEN, Union Wire Rope Corp.

R. O. KASTEN graduated from the Missouri School of Mines with a BS degree in civil engineering in 1943. After graduation, he was employed by Curtiss-Wright Corp. as junior engineer. He then worked for Emerson Electric Manufacturing Co. as a tool designer for a year. In 1944 he accepted a position with Union Wire Rope Corp., now a subsidiary of Armco Steel Corp., in Kansas City, Mo. His first job at Union Wire Rope was to complete work for a MS degree in applied mathematics at Washington university. Made assistant technical director in 1946, he was promoted to director of research and assistant chief engineer in 1949. He was given additional responsibility as manager of quality control in 1958. Mr. Kasten is a member of ASTM, the American Society of Civil Engineers, the Engineers Club of Kansas City and the Missouri Society of Professional Engineers.

Abstract

Wire rope is used in so many diversified fields as the *steel tendons* of industry. Lubrication of these tendons plays a very important role in producing a wire rope to give the ultimate service in the field. Wire rope manufacturers, like any other manufacturer, are charged with the responsibility of producing a high quality product at a reasonable cost. To do this, the wire rope lubricant must possess the following properties: 1. Must not drip off in hot weather; 2. must not become brittle and flake off in cold weather; 3. must adhere or have an affinity to the steel wire; 4. must possess chemical and physical stability; 5. must possess lubricating qualities, plus excellent fatigue life; 6. must be water repellent; 7. must be unaffected by acids, salt water and so forth; 8. the compound must not cake, gum or ball up when contaminated with dust or dirt, and 9. lubricant must meet all government standards.

All lubricant samples are thoroughly tested for these properties and above all are tested on a wire rope fatigue machine. Here, samples of wire rope are made with the various experimental compounds to determine their fatigue or endurance life.

We take pride in making the highest quality wire rope and, consequently, demand the best in lubrication. No one can bargain with quality.

Erwin

Gebhart

New Grease Plant Layout

By M. E. ERWIN, J. C. GEBHART, Gulf Oil Corp.

M. E. ERWIN graduated from Texas A & M College with a degree in chemical engineering in 1934. The same year, he joined Gulf Oil Corp. in the experimen-

tal lab at the Port Arthur, Tex., refinery. He served as foreman in charge of grease plant operations until 1957, when he became superintendent of the package and grease department. From 1941 to 1946, he was a chemical officer in the Air Force, serving as a lieutenant colonel when released from active duty. He is a member of Tau Beta Pi.

J. C. GEBHART graduated from Texas A & M College with a degree in chemical engineering in 1933. He joined Gulf Oil Corp. at Philadelphia, Pa., the same year. He served as foreman at the semi-works grease plant, refinery technology laboratory, Philadelphia from 1935 to 1943. Mr. Gebhart is presently foreman of the package and grease laboratory at the Port Arthur, Tex., refinery. He is a member of the American Chemical Society.

Abstract

A description of Gulf's new grease plant at Port Arthur, Tex., designed for present day manufacturing procedures and completed in 1959, will be given and the general layout of the package and grease department, which handles a full line of petroleum packaged products, discussed. The relationship of the grease plant to the package and grease department, showing the integration of the grease plant into an over-all departmental arrangement, will also be given. An explanation of the five-level elevation and a description of the major items of manufacturing equipment will be among topics covered.

Magie

What's Ahead in Farm Machinery Lubrication

By W. A. MAGIE, JR., Magie Bros. Oil Co.

W. A. MAGIE, JR., received an AB degree in petroleum geology from Harvard College in 1953. Shortly after graduation, he received a commission in the U. S. Naval Reserve and spent the next two years aboard a Pacific Coast destroyer. Released to inactive duty in 1955, he spent the next year working in the laboratory at Magie Bros. Oil Co. In 1956 he joined the Taleen Oil Co. as a farm lubricant salesman covering the central part of Illinois. In 1959 he returned to Magie Bros. Oil Co. as an industrial salesman. Mr. Magie is a member of SAE and is director of the Chicago section of ASLE.

Abstract

The goal of farm machinery designers and lubrication engineers should be a simplification and standardization of farm machinery lubrication. The need for a revamping of present farm equipment lubrication is evident from a study of the situation existing today where there are too many lubricants plus too many service intervals.

This standardization and simplification can only proceed with cooperation between the oil companies and equipment manufacturers and a coordination of their research. In the past research has produced new bearings, new bearing materials, new gear lubricants, new transmissions, new greases, new methods of greasing plus many other innovations. However, some of this research has led to special products that can only be used in one piece of equipment. In the future, we will have to work toward the production of truly multipurpose lubricants so that farm machinery maintenance can still be performed upon the farm.

Armstrong

Discussion on Fellowship Activities

By E. L. ARMSTRONG, Socony Mobil Oil Co., Inc.

E. L. ARMSTRONG received a BS degree in chemical engineering from Purdue university in 1940 and a MChE degree from Brooklyn Polytechnic Institute in 1948. He has been associated with Socony Mobil Oil Co. in the Brooklyn laboratories for 19 years. He is supervisor of the applied research and development section—Brooklyn laboratory of Socony's research department. Author of several U. S. patents dealing with lubricant compositions and processing, he is a member of AIChE, ASLE, ACS, Sigma Xi and the New York Academy of Sciences; is active in ASTM and CRC; and has been a member of fuels and lubricants panel-working groups, Department of Defense. Mr. Armstrong is chairman of the NLGI Fundamental Research subcommittee.

Barnes

New Developments in High Temperature Greases

By R. S. BARNES, Standard Oil Co. (Indiana)

R. S. Barnes has been a member of the research and development department of the Standard Oil Co. (Indiana) since receiving his PhD from Harvard university in 1950. He has worked on the development and testing of automotive, industrial and military lubricants. Dr. Barnes is currently a group leader in charge of development of high temperature fluid and grease products.

Abstract

Future weapons planned by the Air Force will require lubricants to perform over temperature ranges well beyond the capabilities of existing lubricants. Standard Oil Co. (Indiana) is working on a contract aimed at developing greases for lightly loaded bearings to operate from −65°F. to +900°F.; current effort centers on −40°F. to +700°F.

Fluids, thickeners, and lubrication methods superior to those now known are being sought. Many classes of compounds have been tested in newly available high-temperature equipment. Aromatic hydrocarbons, ethers and silicones show promise as fluids, and organic-coated silicas, carbon blacks and glass fibers as thickeners; work to improve and exploit them is underway. Lubrication methods that increase the amount or periodically renew the grease in the bearing perform well and are being investigated further.

Harris

Aero/Space Grease Requirement Trends

By D. N. HARRIS, Shell Oil Co.

D. N. Harris graduated from the University of California with a BS degree in mechanical engineering in 1936. Later that year, he joined Shell Oil Co. in the Martinez motor laboratory and, in 1939, began general product application work. In 1944 he was transferred to the San Francisco head office where he began specialization in the aviation field. He was the aviation member of the Defense Dept. team sent to the Far East in 1952 to survey fuel and lubricant distribution and performance under combat conditions. In 1955 he assumed his present position as chief aviation engineer in the products application department of the New York head office. Mr. Harris is a member of Tau Beta Pi, SAE, IAS, the former NASA fuels subcommittee, the Defense Dept. committees on petroleum distribution methods and equipment and on aviation fuels and lubricants. He is chairman of the CRC aviation fuels, lubricants and equipment research committee.

Abstract

It appears definite that commercial aviation will be operating supersonic aircraft within a relatively few years. The wide temperature range and low ambient pressure under which greases will have to operate will be a challenge which should spur research for new base oils and thickeners. The extremely low pressure conditions of space and the very long operating life necessary for such travel will probably pose the most severe problems for this new grease application of the future. Many lessons will have to be learned regarding lubrication under the conditions of nearly complete vacuum. Certainly, potential applications for new greases developed in the future are numerous and should justify continued research efforts to meet the challenge.

Barnett

The Lubrication Of Nuclear Power Plants

By R. S. BARNETT, Texaco Inc.

R. S. Barnett received his BS degree in chemistry from Southwestern Louisiana Institute in 1929. He then became a teaching fellow at New York university, where he obtained a MS degree in organic chemistry

in 1931. He joined Texaco Inc. in 1931 at the Texaco Research Center, Beacon, N.Y., where he has been ever since. He has been concerned largely with lubricating grease applications, research and analysis with considerable field work and supervisory experience; and more recently with the lubrication aspects of nuclear power plants. He is presently senior technologist, technical services managerial staff. Mr. Barnett is the author or co-author of a number of articles on lubricating grease, fretting corrosion and chemical analysis in NLGI, ASLE, ACS, ASTM and aviation journals. He is listed as co-inventor in seven patents on lubricants, and belongs to a number of ASTM committees and sections. He is also a member of Phi Kappa Phi, Pi Kappa Delta, and Pi Delta Epsilon, ACS, AIC(F) and RESA.

Abstract

A concise review of atomic structure will be given, including the nature of radioactivity, chemical versus nuclear reactions, fission and fusion reactions. The types of nuclear power reactors will be discussed and the status of representative U.S.A. stationery power plants will be given, with information also being presented on nuclear-propelled marine vessels including the N. S. Savannah.

The effect of radiation on petroleum products and organic materials in general will be discussed, including the effect of different particles and rays and their specific effects on oils, greases and petroleum fuels.

Finally lubrication problems in nuclear power plants will be treated, with emphasis on the water-cooled and water-moderated reactors used in the U.S.A.

Langner

Future Package Trends And Designs for Lubricating Greases

By F. W. LANGNER, Socony Mobil Oil Co., Inc.

F. W. Langner graduated from the University of Texas in 1926 and also took graduate work in 1927. Following graduation, he was connected with the Westinghouse organization. In 1931, he joined the Vacuum Oil Co. which later merged with the Standard Oil Co. of New York to become the Socony Mobil Oil Co. Mr. Langner served as technical advisor with his company for three years in Europe and, during the war, acted as chief expeditor of the refinery engineering division in the United States. After the war, he served as chief project engineer. He was given his present assignment as package coordinator in 1950. He has been his company's corporate member of the Packaging Institute since 1950. During that time he has been vice-chairman and chairman of the Petroleum Packaging Committee of the Institute and is presently the chairman of the metal drum and pail subcommittee of the Committee. A director of the Packaging Institute, he is also a member of the American Management Association, Packaging Planning Council.

Abstract

"What is the trend in package designs, and what is being done to bring down or keep the cost of grease packages from rising?" Cost comparisons are given, and in summarized form the work that has been and is being carried on by different committees and trade associations is outlined.

Data from the different tests is given, as well as curves showing the effect of changes in construction of different size packages.

Some new bulk grease handling systems are discussed.

Possible application and use of bulk grease packages constructed of plastic material or metal and plastic are discussed.

Eldridge

Lubricating Grease Requirements of 1961 Passenger Cars

By H. ELDRIDGE, The Chek-Chart Corp.

H. Eldridge received a BA degree from Yale university in 1928. He was associated with the Alemite Div., Stewart-Warner Corp. from 1928 to 1932, and with The Chek-Chart Corp. from 1932 to 1941. He spent four years in the Army Air Force, serving overseas as an intelligence officer. In 1946, he returned to Stewart-Warner where he remained until 1957 when he joined Chek-Chart as executive vice-president. He became president on the death of Ray Shaw. Mr. Eldridge is a member of the American Petroleum Institute.

Abstract

The 1961 car model year brings with it many changes affecting lubrication methods.

With four new U.S.-made compact cars being introduced, bringing the total to ten, compacts form a fast growing section of the lubrication market. Their lubrication requirements are discussed in detail, and since they embody relatively few changes from past practice, they form a bright part of the future lubricant marketing picture.

The most radical changes appear on the standard size cars, where there are many new developments. While a few manufacturers have added lubrication points, some have removed them almost entirely. Yet those who have removed fittings and replaced them with prepacked bearings vary considerably in their instructions for service, some calling for periodic inspection and lubrication service, and others calling for no field service.

Changes in motor oil and gear lubricant requirements are covered in detail, as are the requirements of such units as automatic transmissions and wheel bearings.

In addition, requirements of certain of the newer and more interesting imported cars are discussed together with an over-all summarization of recommendations, and comparisons with the requirements of previous years.

Centralized Lubricating Systems

By R. B. YAHN, Yahn Engineering & Sales Co., Inc.

R. B. YAHN, president of Yahn Engineering & Sales Co., Inc., Palmer, Mass., graduated from Yale university with a BS degree in chemistry in 1943. He was employed by the United States Rubber Co. at its Chicopee Falls, Mass., tire plant as a chemist in the product development group. He has also been employed by the Inland Manufacturing Div., General Motors Corp. as a development engineer, the Flint-Kote Products Co. in product engineering and the C. F. Church Div., American Standard as technical director. In 1952 he was with Ralph Symons Associates, Tiverton, R. I., specializing in hydraulic applications in the rubber and plastics molding field. In 1954 he formed his own company, which specializes in lubrication and hydraulic systems. Mr. Yahn is a member of ASLE, ACS, the Society of Plastic Engineers and the Boston Rubber Group.

Abstract

Half a century ago the only lubricating devices available were oil and grease cups. In 1922 the grease gun and grease fitting were introduced for industrial lubrication. The next step involved piping the bearings to a block with a group of grease fittings in the block and applying the grease gun to each fitting. This led to the introduction of centralized systems about 1930.

Centralized systems for oil can be of the orifice type, piston displacement type, or mist type. For grease, only the piston type can be used. Piston types can be divided into header systems and series systems.

Centralized lubricating systems will reduce repair-maintenance costs. They contribute to uninterrupted production and plant safety. They reduce the costs of applying lubricants. They provide controlled lubrication by metering a known amount of lubricant at a predetermined time.

These systems are precision equipment at moderate cost, capable of producing all of the desirable advantages outlined above. For ultimate performance, the system best suited to the application should be selected, and it should be properly designed and installed. The right lubricant should be used and finally the system should be maintained by trained personnel.

Carter

Rapid Method for Predicting the Flow Properties of Lubricating Greases

By C. F. CARTER, California Research Corp.

C. F. CARTER obtained his BA degree from Polytechnic College of Engineering in 1934. The following year he joined California Research Corp., subsidiary of Standard Oil Co. of California. For the past 17 years, Mr. Carter has been engaged in the development and manufacture of lubricating greases with California Research. An interested member of ASLE, he has been a frequent contributor to the NLGI SPOKESMAN.

Abstract

A rapid test for determining flow properties was developed to screen experimental greases in our research and development programs. The Pressure Flow Test equipment uses a cylinder and a No. 1 capillary similar to that of the ASTM Pressure Viscometer. The piston in the cylinder is operated by compressed gas. The apparatus is portable, weighing less than 16 pounds and can be easily carried from the laboratory to the cold room or any other constant temperature area. It is used for control work for commercial production and can be run as quickly as a worked penetration. This paper describes the Pressure Flow Test equipment and how

we are able to predict the pumpability of a grease as well as other properties related to grease flow.

Oswalt

Wixson

Jenks

Lessons To Be Learned From the Cato Grease Plant Fire

By L. OSWALT, H.WIXSON, R. JENKS, Cato Oil & Grease Company

L. Oswalt joined Cato Oil & Grease Co. in the grease department. He was made foreman of the department in 1938. He served in the Air Force in Europe during World War II. Returning to Cato in 1946, he became supervisor of the oil blending and compounding section. Made plant superintendent in 1948, he was elected vice-president in 1954. Mr. Oswalt is a member of the Society of Automotive Engineers and the American Society of Lubrication Engineers.

H. Wixson received a BBA degree from the University of Michigan. From 1946 to 1953, he was a manufacturer's representative in Ohio, West Virginia and Michigan. He joined Cato Oil & Grease Co. as an assistant in the sales department in 1953. In 1954, he took over specialty sales and the following year became sales manager. He was elected vice-president of sales in 1956.

R. Jenks attended the University of Oklahoma, Texas A & M College and Oklahoma City University Law School. He served as an Air Force captain in Europe during World War II. He joined Cato Oil & Grease Co. in 1955 as secretary and treasurer. He is in charge of administration. Prior to joining Cato, he was Oklahoma manager of Home Indemnity Co. of New York, in charge of sales and administration operations for the state.

Abstract

A million-dollar fire on the night of August 24, 1959 left the Cato Oil & Grease Co. with only three grease kettles that were not completely destroyed. The tremendous problems involved with getting the plant back into production after the fire—having to rebuild the entire plant and operation—on paper, as well as literally; employing a sales force with nothing to sell; and setting up an office with no records—will be discussed. The many safety features of the new Cato plant will be described, along with building construction and dispersement of facilities and equipment.

Welch

Quality Control Tests for Use In Grease Plants

By T. R. WELCH, British Petroleum Co. Ltd.

T. R. Welch graduated from the University of London with a BSc degree in 1952 and was elected an associate of the Royal Institute of Chemistry in 1954. Prior to joining the Research Centre of the British Petroleum Co. in 1956, he was an established civil servant with the department of scientific and industrial research at the road research laboratory where he carried out research on bitumen. At the BP Research Centre, Sunbury, he has worked mainly on greases, marine lubricants and, recently, on bitumens. He is a member of the BP research grease project advisory committee.

Abstract

Most standard grease tests are unsatisfactory for the prediction of the performance of a grease in industrial ball and roller bearings.

An oil release test, suitable for production control of quality in a grease plant, has been developed which shows promising correlation with the bearing rig performance of lithium hydroxystearate greases. It has been shown that the amount of oil released influences the lubricating properties of the grease and that best quality lithium hydroxystearate greases release oil within certain limits.

At present the work is being extended to other types of greases. It seems probable that a reasonable assessment of grease quality will be possible from the deter-

mination of oil release and rheological properties of a grease.

Dooley

The 1958 Food Additives Amendment — Its Effect on The Lubrication of Food Packaging Machinery

By A. E. DOOLEY, Texaco Inc.

A. E. Dooley was graduated from Bethany college in West Virginia. He served as assistant director of the Pennsylvania State Bureau of Industrial Hygiene. From 1942 to 1945, he was a major in the Sanitary Corps, U. S. Army and attached to the Army industrial hygiene laboratory. He has been an industrial hygienist for Texaco Inc. since 1947. Mr. Dooley is a member of the American Industrial Hygiene association, the American Public Health association and the API medical advisory committee. He is also chairman of the API interdivisional committee on labeling.

Abstract

A lubricant manufacturer has no direct responsibility for the safety or quality of a food. He normally has no control over how his products are used. His lubricating oils and greases are made and sold for the lubrication of machinery and are not intended to become components of food. This currently is also the attitude of the Food and Drug Administration.

However, conditions may exist in a food packaging or manufacturing plant where a lubricant is continually getting into the food because of the method of operation, the design of the machinery or the kind of packaging material being used. In these situations, the lubricant might be considered a food additive under the definition used in the 1958 Amendment. The Amendment does not cover the occasional accidental contamination of a food. The FDA had the authority to act in such cases long before the 1958 Amendment.

As of this date, no petroleum lubricant appears in the FDA list of substances generally accepted as safe, in the list of permissible food additives or in the list of substances for which prior sanctions have been granted. An extension has been given for the use of mineral oil for certain limited uses but the grade authorized under the extension is not generally considered a lubricant.

Extensions may still be requested for materials in use before January 1, 1958 but all extensions cease next March 5. There is no provision for any extensions beyond that date.

Sisko

Brunstrum

Permeability of Lubricating Greases

By A. W. SISKO, L. C. BRUNSTRUM,
Standard Oil Co. (Indiana)

A. W. Sisko graduated from Syracuse university with an AB degree in chemistry in 1942. He received his PhD in physical chemistry from Case Institute of Technology in 1956. He is now in the research department of the Standard Oil Co. (Indiana) at Whiting. He is a member of the Society of Rheology, Sigma Xi and ACS.

L. C. Brunstrum has been a member of the research department of the Standard Oil Co. (Ind.) since he received his BS degree in chemical engineering from Armour Institute of Technology in 1929. He is currently the section leader in charge of research on greases and industrial lubricants. Active in ASTM, he is a member of ACS, the Society of Rheology and ASLE. He was appointed chairman of the NLGI Technical Committee at the 1959 annual meeting. In 1958, he was the seventh man to be honored by the "Award of Achievement," after five years as Technical committee vice-chairman.

Abstract

The permeability of pastes and gels should give useful information about the network of thickener particles in these colloids. An apparatus has been designed and used for measuring the permeability of lubricating greases. Equations for calculating permeability from the flow rate of the oil through the network are presented. Grease permeability is related to the retention of oil by the particle network and is a measure of particle dispersion. Permeability gives information about the thickener network unobtainable by conventional methods—electron microscopy, x-ray diffraction, rheology.

Suggitt

Structural Changes And Phase Transitions In Lithium Greases

By R. M. SUGGITT, Texaco Inc.

R. M. SUGGITT graduated from the University of Toronto with a BA degree in 1947. He received a PhD in physical chemistry from the University of Michigan in 1952. He has been associated with Texaco Inc. since that time. A group leader at the Texaco research center, Beacon, N.Y., Dr. Suggitt has centered his interests mainly in the fields of surface and colloid chemistry. He is a member of ACS, RESA and the Society of Rheology.

Abstract

Phase transitions sometimes play an important role in understanding the structural changes in greases. They mark the temperature ranges wherein a particular crystalline form is thermodynamically stable.

In this paper the phase transition temperatures and qualitative heats of transition as determined by differential thermal analysis are presented for lithium fatty acid soap greases as a function of chain length over the range C_{10} to C_{22}. Electron microscopy has been used to study the structural forms or soap/oil samples subjected to various thermal treatments. It was found that fiber development occurs at one specific phase transition and that long lithium soap fibers can be formed statically with a suitable heat treatment.

The results are used to suggest the types of crystal structure changes that may take place at the phase transitions.

Wilson

Electron Microscope Examination of Thin Sections of Lubricating Grease Thickeners

By J. W. WILSON, JR., Socony Mobil Oil Co., Inc.

J. W. WILSON, JR., received his AB degree from Amherst college in 1938 and studied at M.I.T. the following year. He started his career with Socony Mobil Oil Co., Inc. in the summer of 1934 as a service station attendant. While still attending school, he worked in the research department at the Brooklyn laboratory as a summer employee from 1936 to 1939. In 1940 he joined the staff as an analytical chemist. He is currently a senior technologist in the applied research and development division of the Paulsboro, N. J., laboratory. Mr. Wilson is a member of the American Chemical Society and the Electron Microscope Society of America. His published work has dealt with the color of petroleum products, microscopic studies of the structure of lubricating greases and special techniques for use in electron microscopy.

Abstract

For some thirty years it has been recognized that the structure and arrangement of the thickener particles in lubricating greases made a major contribution to their properties. During this period advancing techniques have increased our knowledge of these particles. This paper represents a further contribution.

Electron micrographs of ultrathin sections (2,000,000 to the inch) of calcium-lead complex and lithium-calcium grease thickeners are shown. The sections of the lithium-calcium grease show both transverse and longitudinal cuts of the thickener fibers. There are some indications of ordered areas of structure within the fibers. Non-planar configuration is exhibited by some of the fibers. The sections of the calcium-lead complex thickener show several structures varying from amorphous material to particles having a definite organization but non-uniform cross section. The sections were prepared by extracting the oil from thin films of grease, staining the thickeners with osmium, embedding in methacrylate polymers, and finally cutting with an ultramicrotome. For comparison, electron micrographs are shown of the thickeners as conventionally prepared by suspension in petroleum ether and shadowcasting.

This method is leading toward the reconstruction of three-dimensional structure of a lubricating grease thickener through the examination of serial sections.

Forster

A Rheological Equation for Lubricating Greases

By E. O. FORSTER, Esso Research & Engineering Co.

E. O. Forster received his BS and a PhD degree in physical chemistry from Columbia university in 1949 and 1951, respectively. Since then he has been engaged in lubrication research with Esso Research & Engineering Co., where he is presently a research associate in the central basic research laboratory. A member of ASLE, ASME, ACS and the Society of Rheology, Dr. Forster received the Alfred E. Hunt memorial medal from ASLE this year. Author of numerous articles in the field of greases and lubrication, he holds ten U. S. patents in the field of lubrication. He is vice-chairman of NLGI's Fundamental Research committee.

Abstract

Based on theoretical considerations, a rheological equation for greases has been developed which permits to predict the flow behavior of greases over all ranges of shear stresses or shear rates from a knowledge of the yield stress, τ_o, the ultimate viscosity, η_∞ (viscosity at infinite shear) and a few experimental points. This equation has the form $(\tau-\tau_o)^n\ (\eta-\eta_\infty)=K$, where n and K are parameters characteristic of the soap type, the soap concentration, and the method of manufacture followed. Several types of greases are shown to follow this equation and the plot of log $(\tau-\tau_o)$ versus log $(\eta-\eta_\infty)$ produces a straight line of slope n. Because of this linear relationship, extrapolation to high shear stresses should become much simpler and more meaningful.

Goodrich

Burke

Oxidation of Lubricating Greases

By J. E. GOODRICH, California Research Corp. and

J. J. BURKE, George Washington High School, San Francisco

J. E. Goodrich received his AB and MA degrees from the University of Kansas in 1947 and 1948, respectively. He obtained a PhD in organic chemistry from the University of California in 1951. He was a destroyer escort radar officer in the U. S. Naval Reserve from 1943 to 1946. He has been a research chemist with California Research Corp., specializing in burner fuels, chemicals and lubricating greases, since 1951. Dr. Goodrich is a member of ACS, Sigma Xi, Alpha Chi Sigma, Phi Beta Kappa and Phi Lambda Upsilon.

J. J. Burke received AB and MA degrees from the University of California and his teacher's credential from Stanford university. Since 1936 he has been a teacher at George Washington high school, San Francisco, where he is presently head of the science department. He has received a number of fellowships including: Federation of Paint Production Clubs fellowship, University of North Dakota (1956); National Academy of Science fellowship, Michigan State (1957); National Science Foundation fellowship, Ohio State (1957-58); and Atomic Energy Commission fellowship, Lawrence Radiation laboratory, University of California (1960). He is a member of five teachers associations and on the Northern California Science committee.

Abstract

A study has been made of the oxidation of greases using the oxygen bomb test. Soap gelling agents are known to catalyze the oxidation of the base oils. It has been found that the catalytic activity of stearate soaps decreases going from lithium to aluminum in the periodic table. Excess acid accelerates the oxidation of greases; excess base retards it. The degree of oxidation of a grease may be determined by observing the magnitude of the carbonyl band in the infrared spectrum. The chief volatile oxidation products are carbon dioxide and carbon monoxide; the chief nonvolatile products are esters and low molecular weight carboxylic acids. Further work remains to be done to explain the mechanism of the catalytic effect of soaps in greases.

Dudley

Engineering Considerations in The Use of Grease As a Gear Lubricant

By D. W. DUDLEY, General Electric Co.

D. W. Dudley received a BS degree in mechanical engineering from Oregon State college in 1940. His

first engineering work was with the General Electric Co., on its test program. In 1948, he became section head of the development section of the gear engineering division, in which he was responsible for gear development and testing, as well as the design and development of special tools and machinery for making gears. In 1953 he became supervisor of gear advance and development engineering. Four years later, he was named manager of the advance unit of the gear engineering subsection, medium steam turbine, generator and gear department. Author of several technical articles for the trade press, Mr. Dudley has also written a book entitled "Practical Gear Design." A member of ASME and the American Gear Manufacturer's Association, he received the Edward P. Connell award from AGMA in 1958.

Kim

Ree

Eyring

Thixotropic Behavior Of Grease

By KAK-CHOONG KIM, T. REE, H. EYRING, University of Utah

KAK-CHOONG KIM graduated from Berea college, Berea, Ky., with a BA degree in chemistry in 1956. He received a MS degree in physical chemistry from the University of Utah in 1959. He is presently working for a PhD degree in physical chemistry at the University of Utah, where he is the current NLGI Fellow.

T. REE has been a research professor in chemistry at the University of Utah since 1949. He received BS and ScD degrees in chemistry from Kyoto Imperial university, Japan, in 1931. He became a professor in chemistry there following graduation and achieved professorship in 1943. In 1945 he was named dean and professor of the college of liberal arts and sciences at the Seoul National university, Korea, where he remained until taking his present position at the University of Utah. Dr. Ree has devoted his time to the study of chemical kinetics, catalysis, reactivity of organic substances, rheology and quantum chemistry.

H. EYRING has been dean of the graduate school at the University of Utah since 1946. He is also associate editor of the *Textile Research Journal*. He was research director of the Textile Foundation from 1944 to 1946, worked with the Office of Science Research & Development, U. S. Navy in 1944, and received the alumni achievement award from Arizona university in 1947. Dr. Eyring received the degrees of BS and MS from Arizona university, PhD in chemistry from California, and honorary science degrees from Utah in 1952, from Northwestern in 1953 and from Princeton in 1956. He is a member of the National Academy, Soc. Rheol., winning the Bingham medal in 1949, Chem. Soc., winning the Nichols medal in 1951 and Philos. Soc.

Abstract

Thixotropic behaviors of silica gel grease, bentone grease and calcium soap grease have been studied by using an autographic rotational viscometer.

Careful observations were made on the stress relaxation behaviors of greases at different shear rates and on the effect of resting time for recovery on the flow curves of greases. The experiments were carried out at the various experimental conditions; i.e. different temperatures and different rates of change of the shear rate. The effect of the thickener concentration on the flow properties was also studied for each type of grease.

The experimental results are summarized as follows:

1. In the first measurement, a hysteresis loop with a fair size was observed.

2. The hysteresis loop was decreased with the successively repeated measurements to a certain size which depends on the particular sample used.

3. Then the size of the loop was retained (no decrease or increase) almost irrespective of the resting time.

4. In the up-curve of the stress relaxation experiment, a general tendency of stress decay was observed at each shear rate set for the experiment.

5. In the down-curve, an increasing tendency of the stress was observed.

These experimental results are discussed in relation to the theories of the structure of thickener-oil dispersions. ■

Effect of Oil Viscosity on Rheological Properties of Lubricating Greases

By: B. W. Hotten
A. L. McClellan
California Research Corp.

RELATIONSHIPS between the rheological properties of plastic suspensions and those of their suspending liquids are interesting theoretically and important practically.

Theoretical interest goes back to Einstein's equation[1] for very dilute suspensions of noninteracting spherical particles,

$$\eta_G = \eta_0 (1 + kc) \qquad (1)$$

In this equation η_G is the viscosity of the suspension, η_0 that of the suspending liquid, and c the volume concentration of the suspended material. Attempts to expand eq. 1 and to develop other equations to fit more concentrated suspensions are reviewed by Frisch and Simha.[2] But the lack of precision and generality of these equations, especially for systems in which the suspended particles form a structural network, proves the need for more experimental and theoretical study.

Practical applications of such rheological relationships are made in paints, plasticized resins and lubricating greases. Thus, the critical properties of pumpability, torque in rotating bearings and film thickness of lubricating greases depend on their viscosity. Grease viscosity in turn depends on the viscosity of the base oil.

One limitation on progress in the systematic study of viscosity relationships of suspensions has been the difficulty of isolating the variable of viscosity of the suspending liquid. Conventional liquids that vary in viscosity also vary chemically; this may change the colloidal structure, and consequently the flow properties, of the suspension as much as the differing liquid viscosity does. This difficulty was overcome in our experiments by the use of a series of polyisobutene oils that increased in viscosity because of increasing molecular weight, without accompanying variation in chemical type.

TABLE I
Polyisobutene Oils

Oil	*Average mol. wt.*	*Viscosity at 25°C. poises*
PB-8	370	1.36
PB-8/12[a]	450	4.75
PB-12	530	18.5
PB-16	570	33.8
PB-20	670	99.0
PB-24	840	189

(a) A 1:1 mixture of PB-8 and PB-12.

Procedure

The six polybutene oils used for grease preparation were made by Oronite Chemical Co.; their properties are listed in Table I. These oils were gelled by four

TABLE II
Shape and Size of Crystallites in
Polyisobutene Greases as Seen in Electron Micrographs

Gelling Agent	*Polybutene oil viscosity at 25°C. poises*	*Shape*	*Crystallite structure*		
			Length, μ	*Width, μ*	*Thickness μ*
Thermally dispersed					
Aluminum benzoate stearate	1.36-189	Rods	0.1-0.2	Diameter increased from 0.01-0.02 in least viscous oil to 0.03-0.04 in most viscous	
Lithium stearate	1.36-18.5	Ribbons	0.4-0.9	0.1	0.01-0.05
	33.8		0.5-1	0.08-0.1	0.01-0.05
	99.0		0.5-1.2	0.08-0.12	0.01-0.05
	189		0.5-2	0.1-0.2	0.01-0.05
Mechanically dispersed					
Lithium stearate aerogel	1.36-189	Ribbons	0.2-1	0.08-0.1	0.05
Silica aerogel	1.36-189	Clustered spheres		Diameter 0.01	
Bentone 34	1.36-189	Flakes		0.5-1.0	Less than 0.01

gelling agents with the aid of two dispersion techniques. The soaps, lithium stearate (Witco Chemical Co.) and basic aluminum benzoate stearate,[3] were heated in the oils to 200°C. and the mixtures pan-cooled and milled through an Eppenbach colloid mill.

Greases were also made from lithium stearate which had been predispersed thermally in mineral oil, the oil extracted with hydrocarbon thinner followed by liquid butane, and the butane released above its critical temperature, leaving an aerogel.[4] The aerogel was dispersed in polybutene oils by means of a three-roll mill. Silica aerogel (Monsanto "Santocel") and Bentone 34 (alkylammonium bentonite clay made by National Lead Co.) were dispersed in the oils in the three-roll mill.

Consistencies of the gels in terms of yield pressures (calculated from the weight and contact area of the penetrometer cone) were measured by ASTM Method D 217-52T. Electron micrographs of the gels were made on hexane-washed and uranium-shadowed samples with an RCA Model EMU electron microscope. Apparent viscosities were measured in a pressure viscometer with capillaries having a length-to-diameter ratio of 40 to 1, as described in ASTM Method D 1092-55.

Results

Structure of Gels—The size and shape of the crystallites forming the gel structures, as seen in electron micrographs, are summarized in Table II. Crystallites of the two thermally dispersed soaps increased in one or more dimensions as the viscosity of the oil in which they were dispersed increased. Thus, studies of effects of properties of the suspending liquid on colloidal systems should be interpreted with care when the colloidal structure is formed *in situ*—variables may exist in both phases. The crystallite structures of the three preformed, mechanically dispersed gelling agents listed in Table II were unaffected by the viscosity of the suspending liquid. Shapes varied from ribbons for the lithium stearate to spheres for the silica, and puckered flakes for the Bentone.

Sedimentation tests gave more evidence on the micro-structure of some of the gels. Grease samples of 12.5 g. were dispersed in 250 ml. diethyl ether and the dispersions allowed to settle in graduated cylinders. Sedimentation volumes in milliliters of soap floc from the lithium stearate greases after fifteen days were:

Oil	PB-8	PB-8/12	PB-12	PB-16	PB-20	PB-24
Thermally dispersed	185	156	185	141	100	64
Aerogel	94	-	94	96	80	60

The sedimentation volumes indicate a sharp decrease in degree of dispersion of the thermally dispersed soap and little variation in that of the aerogel soap with increasing oil viscosity. The silica aerogel sedimentation volume leveled off at 70-80 ml. after four hours for all the oils.

Consistency of Greases—Results of consistency measurements are in Table III. Oil viscosity affected the consistency of thermally formed greases differently from that of mechanically formed greases.

The thermally dispersed lithium stearate generally gave softer greases (both unworked, and worked 60 strokes through a perforated disk) as oil viscosity was increased. This result correlates with both electron micrograph and sedimentation observations, which showed that this soap formed coarser crystallites in the more viscous oils. Aluminum benzoate stearate also gave softer greases as oil viscosity was increased, with a sharp drop in stiffness in the two most viscous oils. The oils of higher viscosity apparently reduce crystallite nucleation.

TABLE III
Consistency of Polyisobutene Greases
(Kilodynes/sq. cm. at 25°C.)

	Concn., wt. %		Polyisobutene viscosity at 25°C. poises					
			1.36	4.75	18.5	33.8	99.0	189
Thermally dispersed								
Aluminum benzoate stearate	14	unworked	37.0	25.2	31.4	38.4	5.98	3.2
		worked	31.4	25.2	16.2	14.0	4.9	3.62
Lithium stearate	14	unworked	23.6	20.4	11.0	8.42	4.51	4.70
		worked	11.9	12 7	7.55	10.1	4.41	4.90
Mechanically dispersed								
Lithium stearate	14	unworked	13.8	—	33.1	14.6	24.0	28.7
		worked	10.9	—	22.1	11.8	18.7	20.2
Silica aerogel	10	unworked	36.2	68.5	83.2	118	127	230
		worked	12.0	45.4	44.4	50.2	68.5	75.5
Bentone 34	15	unworked	36.2	52.1	33.7	52.1	88	460
		worked	6.27	9.11	8.22	30.4	12.4	21.4

The stiffness of greases made by mechanical dispersion at low temperature, on the contrary, generally increased logarithmically with increasing oil viscosity. The unworked consistency of the silica and Bentone greases was especially stiff for the most viscous oil. The large difference between unworked and worked consistencies of the silica gels in high-viscosity polybutenes and of the Bentone gels in all the polybutenes shows that some bonds among the crystallites are easily

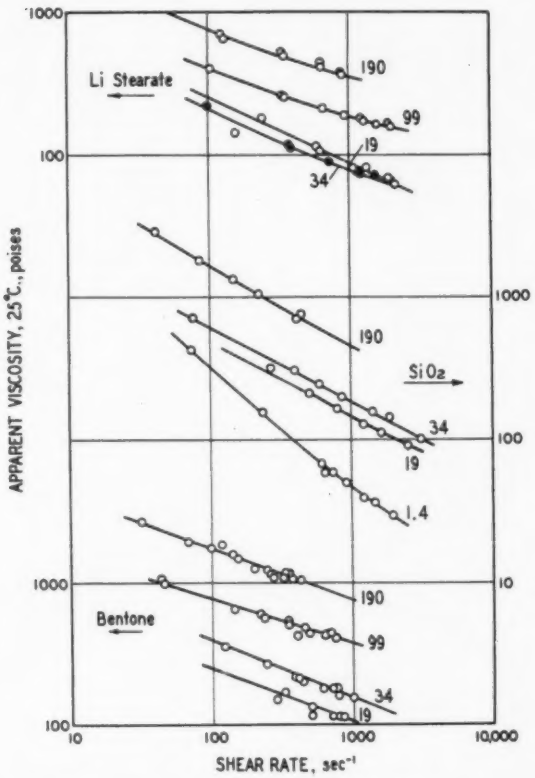

FIGURE 1—Effect of polyisobutene viscosity on apparent viscosity of polyisobutene greases mechanically formed with 14 per cent lithium stearate aerogel, 10 per cent silica aerogel and 15 per cent Bentone 34. Numerals on curves are polyisobutene viscosities at 25°C. in poises.

broken. An oil with high viscosity could stiffen a gel either by strengthening intercrystalline bonds or by resisting displacement in spaces among the crystallites.

Apparent Viscosity of Greases—Apparent viscosity-shear rate curves of mechanically formed greases are shown in Figure 1. The silica greases at 10 per cent concentration apparently had a more delicate structure than the lithium stearate (14 per cent) and Bentone (15 per cent) greases; the silica greases lost viscosity faster with increasing shear rate than the two series of more concentrated greases.

TABLE IV

Constants of Grease Viscosity-Shear Rate Curves for Mechanically Formed Greases

Oil viscosity, η_o, poises	*Intercept, a*	*Slope, m*
	Lithium stearate greases	
19	2000	-0.45
34	1500	-0.42
99	1900	-0.33
190	3600	-0.34
	Silica greases	
1.4	(5,300)	(-0.68)
19	6,000	-0.54
34	7,100	-0.53
190	17,000	-0.56
	Bentone greases	
19	1400	-0.38
34	2600	-0.41
99	3400	-0.32
190	9200	-0.36

Discussion

The reasonably straight lines obtained for logarithmic plots of grease viscosity against shear rate may be described by the equation,[5]

$$\eta_G = aS^m, \qquad (2)$$

where S is shear rate and a and m are constants. The constants calculated from Figure 1 are in Table IV. The intercept, a, the grease viscosity extrapolated to a shear rate of 1 sec.$^{-1}$, generally increased with oil viscosity. The slope, m, is nearly constant within each series of greases; thus, it must depend mainly on the gelling agent. The silica greases, which contained a lower concentration of gelling agent for comparable consistency than the lithium stearate or Bentone greas-

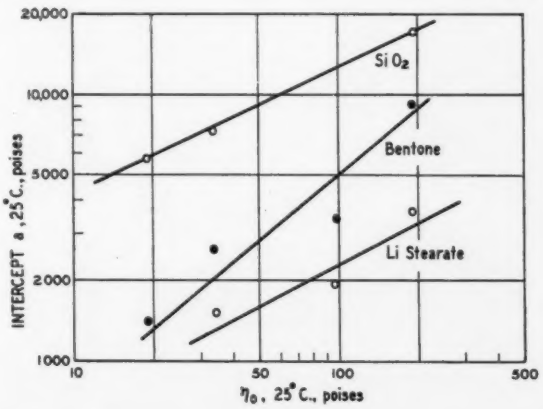

FIGURE 2—Relationship between intercept of eq. 2 (grease viscosity at shear rate 1 sec.$^{-1}$) and polyisobutene viscosity in polyisobutene greases made with three gelling agents.

es, gave the highest and most varied slopes. (The low-shear portion of the silica grease made from the lowest viscosity oil appears abnormal. Calculations were based on the extrapolated linear portion of this curve.) Studies by such workers as Arveson[6] and Sisko[7] show that logarithmic viscosity-shear rate curves, especially for softer greases, level off at higher shear rates. Thus, eq. 2 cannot be extended to very high shear rates.

Relationships between grease viscosity and oil viscosity were examined in three shear rate regions: very low, medium and very high.

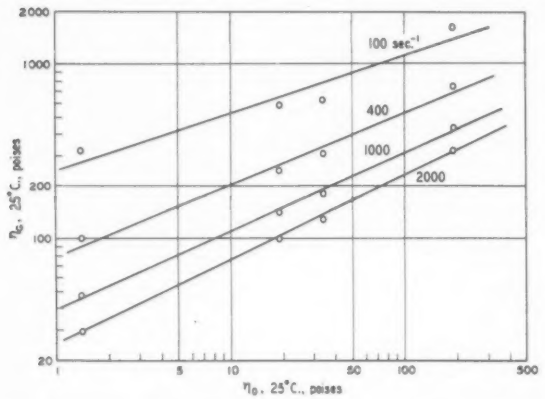

FIGURE 3—Relationship between apparent viscosity of silica-polyisobutene greases and polyisobutene viscosity at varying shear rate.

The intercepts of eq. 2 were used for the very low shear rate region. These intercepts for the three series of gels showed logarithmic relationships (Figure 2) with η_o, which may be expressed as

$$a = b\ \eta_o^n \qquad (3)$$

Combination of eq. 2 with eq. 3 gives

$$\eta_G = b\ \eta_o{}^n S^m \qquad (4)$$

which describes approximately the relationship between the viscosity of the gel and that of the oil for low shear rates.

A more general form of eq. 3 fitted the silica greases at higher shear rates:

$$\eta_G = b\ \eta_o^n \qquad (5)$$

where b and η varied with shear rate (Figure 3). But below 100 sec. $^{-1}$, the logarithmic plots were curved.

The lithium stearate and Bentone greases gave straight lines when $\sqrt{\eta_G}$ was plotted against oil viscos-

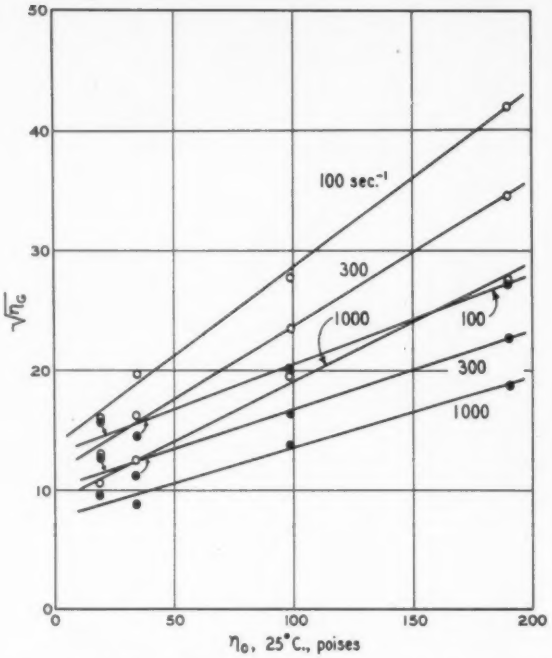

FIGURE 4—Relationship between square root of apparent viscosity of polyisobutene greases and polyisobutene viscosity. Gelling agents are Bentone (open circles) and lithium stearate (solid circles). Shear rates are shown on curves.

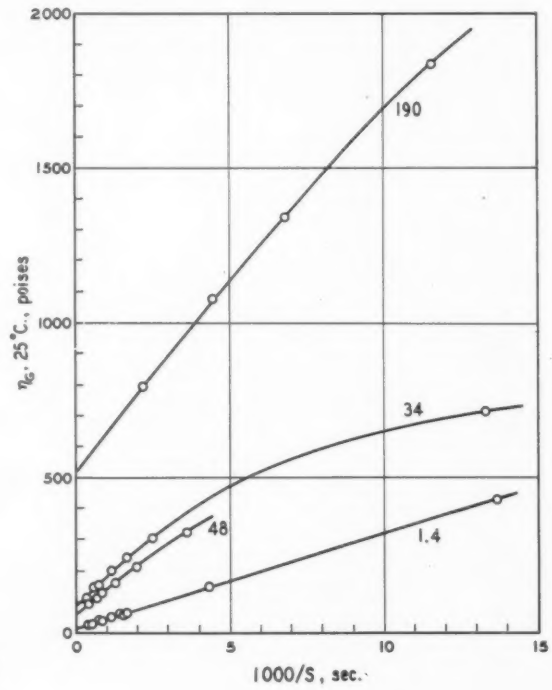

FIGURE 5—Nearly linear relationship between apparent viscosity of silica-polyisobutene greases and reciprocal shear rate at very high shear rates (low reciprocals). Polyisobutene viscosities in poises at 25°C. are shown on curves.

ity, as in Figure 4. This relationship may be written as

$$\sqrt{\eta_G} = r\eta_0 + t \quad \text{or}$$

$$\eta_G = t^2 + 2rt\eta_0 + r^2\eta_0^2 \qquad (6)$$

The constants r and t varied with gelling agent and shear rate. The quantity, t^2, may have some physical significance as the viscosity contribution of the gelling agent without oil. The silica greases did not fit eq. 6 when the lowest viscosity oil was included.

For relationships at very high shear rates, grease viscosity was plotted against reciprocal shear rate, as in Figure 5. The resulting curves were linear at the highest shear rates, resembling curves obtained by Storey and Merrill[8] for amylose and amylopectin solutions; to account for such curves, they modified Goodeve's impulse theory[9] for a system of linkages based on hydrogen bonds between the solute molecules. The silica greases gave the most linear plots, but the Bentone and lithium stearate grease plots were also sufficiently linear to permit extrapolation to infinite shear rate. When such extrapolations were plotted against oil viscosity, as in Figure 6, straight lines going through the origin were obtained. This is the relationship expected from Einstein's equation. It suggests a high degree of independence among the suspended crystallites, even at high concentrations of gelling agent, for gels flowing at very high shear rates.

The most general equation relating viscosity of a grease with that of its oil, for a wide range of flow rates, will probably be obtained by addition of the low and high shear rate components of eqs. 4 or 6 and eq. 1:

$$\eta_G = x\eta_0 (1 + kc) + yb\eta_0 {}^nS^m \qquad (7)$$

where x is the fraction of gel in fluidized flow and y the fraction in plastic flow.

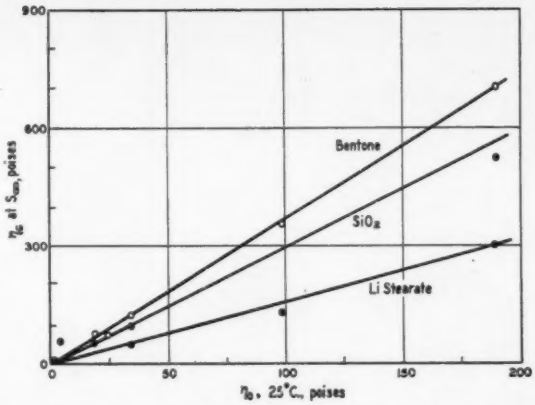

FIGURE 6—Apparent viscosities of polyisobutene greases extrapolated to infinite shear rate are directly proportional to polyisobutene viscosity, in agreement with Einstein's equation.

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B. W. Hotten *graduated from Cincinnati university in* 1941 *with a BA degree and received his PhD in organic chemistry from Purdue university in* 1945. *He spent an additional year at Purdue in research on organic fluorine compounds. Since* 1946, *Dr. Hotten has worked on the formulation and fundamental properties of lubricating greases at California Research Corp., where he is senior research chemist. His membership in various organizations includes Phi Beta Kappa, Sigma Xi, the American Chemical Society and the Society of Rheology. He has contributed to the* Spokesman *previously.*

About the Authors

A. L. McClellan *graduated from Centenary college of Louisiana. He received his MS and PhD degrees from the University of Texas and completed postdoctoral studies at the University of California and MIT. In* 1951 *he joined California Research Corp., where he is presently senior research chemist. A previous contributor to the* NLGI Spokesman, *Dr. McClellan is the author of twelve papers on lubricating greases, infrared spectroscopy, and corrosion. He is coauthor of a book, "The Hydrogen Bond."*

A PHILOSOPHY OF

By: M. Ehrlich
American

Manufacturing Symposium—V

(*Conclusion*)

SOME lubricating grease manufacturers have been milling greases for years; others have never taken the plunge. Even advocates of milling may not mill all greases, and may use different techniques with different types of mills. Therefore a measure of confusion is inevitable.

Some have employed a technique called "kettle milling," in which the kettle agitator is used as a mill. This raises a question—if kettle paddles act as effective milling devices, why purchase costly mills? It is hoped in this paper to show that there is a physical basis for the use of mills. Some excellent papers in this field have previously been presented before the NLGI.[1,2,3]

A rigorous mathematical treatment is not today possible, but the use of a few formulae may clarify some points. Since many people intimately concerned with the manufacture of lubricating greases may be repelled by mathematics, equations may be expressed here in words rather than, or along with, symbols.

Sir Isaac Newton established two relationships which are widely recognized and used.

For elastic solids—
stress is proportional to strain
stress = a constant times strain. $F = kS$ or
This constant (k) is sometimes known as elastic modulus

For conventional fluids—
shear stress is proportional to shear rate or
shear stress = a constant times shear rate. $F = \mu S$
This constant (μ) is known as viscosity

Not all solids or fluids follow these equations. The non-conformist solids are called inelastic; fluids, non-Newtonian. Lubricating greases are among the non-Newtonian fluids. Shear rate is not proportional to shear stress. This relation may be expressed in the form of an equation as:

Shear stress = a variable times shear rate

In current grease literature this variable is called *apparent viscosity*. At the right time and place, a discussion might be in order to air views on whether what is called *apparent* viscosity would not be better termed nominal or *effective* viscosity.

The very fact of a variable relation between shear stress and shear rate indicates that some of the energy applied to a lubricating grease does not lead to flow, but affects the internal structure of the grease. Whether this effect is permanent or temporary must depend on:

(1) the nature of the grease
(2) the nature and severity of the shear stress applied.

GREASE MILLING

and F. S. Sayles
Lubricants, Inc.

Presented at the NLGI 27th annual meeting in New Orleans, October, 1959

How does this apply to a grease kettle? Shear stress is related to the design of the kettle; viscosity to the formulation of the grease. Shear rate results from both of these. If this last point is not clear, we should return to an earlier formula:

shear stress = viscosity times shear rate ($F = \mu S$)

Transposing:

shear rate = shear stress divided by viscosity

$$(S = \frac{F}{\mu})$$

If we consider this formula, we may visualize the viscosity of kettle contents as part of the stirring system of the kettle. The experience of most grease manufacturers indicates that the usual kettle–agitator system has its greatest structural effect on greases of high viscosity.

Can we alter the design of a kettle so that agitator effectiveness will be increased as viscosity decreases? We may turn to studies in viscometry for guidance.

Significant factors for cone-and-plate viscometry[4] are:

distance between two surfaces in relative motion
torque
speed of rotation
shear history
temperature
viscosity

The first three of these are related to kettle design. If we want to consider a single-motion kettle with breaker arms between paddle arms, design factors are the spaces between arms and breakers, horsepower available, and speed (which in turn is affected by both diameter and rpm).

Increasing power alone is an illusion, since the rated horsepower of a motor will be delivered only when demand is high. In making a batch of grease, maximum power may be drawn for a small part of the cycle. A record of power actually utilized during a production cycle may be obtained by noting amperage drawn as grease is being manufactured. Some typical points are shown for a conventional open-kettle-cooked wheel-bearing grease manufacturing process.

	Amps
Start	55
1 hour of heating	60
Oil started slowly	115
Start to cool	75
Dragging hard	150*
Most of oil added	85
All oil in	75

*maximum for this motor. Batch size is controlled by this reading.

FIGURE 1.

Increasing speed is practical, to a point. This may be accomplished by increasing kettle diameter, or RPM, or both.

A drastic increase from the conventional leads to design nightmares as to horsepower requirements and mechanical problems, such as rigidity of paddle shafts and arms, and loading of bearings. Sometimes smaller diameter supplementary agitators are used at higher rpm.[5]

Decreasing space between paddles and breakers would seem a quite rewarding approach. Since a grease kettle is so different from a viscometer, formulae are not easily derived. But it seems probable that the relation of viscosity to flow of grease between parallel planes can lend guidance. A basic formula[6] states that

$$F = \frac{A\ \mu V/t}{D}$$

F = force required
A = area
μ = viscosity
* V/t = velocity
* D = thickness of film

(* these have been changed to agree with the designation in Figure 3.)

FIGURE 2.

Here force is used to slide one plate over another at a constant velocity. If, however, the viscosity of a grease is derived by pumping through a narrow slit, the formula would look like[7]:

$$\mu = \frac{\frac{PD}{2L}}{\frac{6V/t}{WD^2}} = \frac{PWD^3}{12L\ V/t}$$

P = pressure
W = width of slit
L = length of slit

FIGURE 3.

These formulae bear out thoughts expressed earlier—that increased power and speed would be helpful. They indicate also that the space between paddle arms and breakers should be small. If this spacing (D) is affected mathematically as indicated in Figure 3, its value must be cubed. Then the greatest possibilities for increasing effectiveness will be found here, since halving this space would be four times as effective as doubling speed.

To try to run existing kettles with spaces between paddles and breakers of only a small fraction of an inch, would be mechanically unsound. Consider, though, the possibility of a miniature grease kettle, perhaps 6 or 7 inches in diameter. Because of the small diameter, speed must be increased to maintain agitation effectiveness. In this small size, agitator arm rigidity, shape, and placement are easily controlled; therefore the agitator may be driven at full speed. Breaker arms may be used as before, mounted rigidly. Then to maintain close spacing, the faces of both agitator and breaker arms may be precision ground. In use, the blades would cut channels through the grease, resulting in no agitation at all. Suppose though that the kettle body were fitted into a line, and the contents pumped through repeatedly. This would approach an idealized agitation system, and may be used as a super kettle-agitator-type mill. One change is practical, and even preferable. Instead of breaker arms, perforated plates are used. Such plates give the effect of a large number of arms, and greater rigidity. A grease mill of this type[8] was designed by us over a decade ago. A number of such units have been in use since, in several sizes and modifications.

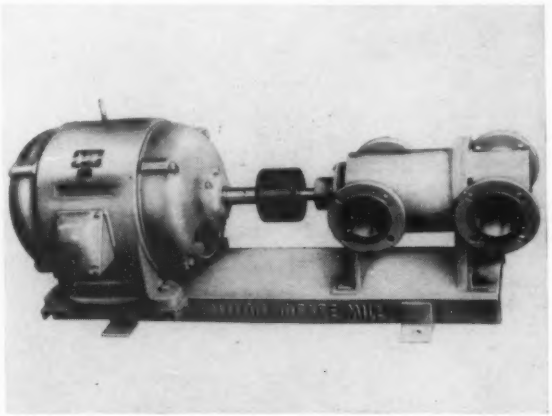

FIGURE 4.

The mill so derived has been discussed informally with a number of grease men over the years. Certain questions usually come up. It seems desirable to anticipate and answer such questions here; they fall in three areas:

(1) Characteristics of the mill
(2) How it has been used or may be used
(3) How well it works

We hope to be forgiven for citing our experience in answer.

The mill is not adjustable. Internal dimensions are such as to produce clearances in the order of 0.001 inch between moving (blade) and stationary (plate) surfaces. The grease is pumped through the mill at varying temperatures, creating stresses. Expansion and possible flexibility of the flat surfaces make an exact determination of clearance difficult. We do know that adjustability of mills raises as many problems as it solves. (With this one, nobody fools around with the adjustment).

The grease mill has a series of plates and blades; it is therefore a multi-stage mill. An earlier model, No. 6, had four plates and three blades, was driven by a 20 hp, 1750 rpm motor. It was fed by a 3-inch pump driven by a 15 hp motor, and delivering 100 gal/min or about

40,000 lbs./hr. It may be considered to have six stages. The latest unit, No. 7, is driven by a 30 hp motor, and has one more plate and one more blade, therefore two more stages. Shear surfaces are at the front and back (as well as the periphery) of each blade. It seems likely that, under stress, clearance at the front of each blade is less than at the back; if so, these are the most effective shear surfaces.

Since the mill is a supplement to the kettle agitator, it is best used, not for a final touch-up, but while kettle contents are being stirred as usual. In this way, milling does not consume extra time. During a part of usual kettle processes, grease is pumped out of the bottom of the vessel, through a circulating line, and back into the top. The mill is piped into this line with suitable valves, so that it may be used or not, as desired.

Some of the gains have included economy, speed, uniformity and smoothness, although these may not all be obtained on the same product. It should be noted also that with this accessory, a kettle which might otherwise be considered obsolescent due to an ineffective stirrer, is converted into highly efficient mixing equipment. Kettle contents are subjected to far greater shear stresses than would be possible with even the best of conventional paddles.

Grease passing through this mill heats up slightly. The amount of heating depends on many factors, but is low enough for normal kettle cooling to be carried out. While milling, the temperature of the grease drops. The lowest temperature so achieved depends on the cooling water available; any figures cited might prove misleading.

If a grease can be pumped, it can be handled in this mill. Flow patterns in a grease kettle or a grease mill are complex. Establishing the shear rates in this equipment would thus be difficult. But shear rates in a conventional grease kettle are relatively low, and in a grease mill, high. It would seem offhand that to handle bearing greases at the speeds utilized must require enormous strength and power. Such fears may be dispelled if we analyse some apparent viscosity curves, taken on different greases.

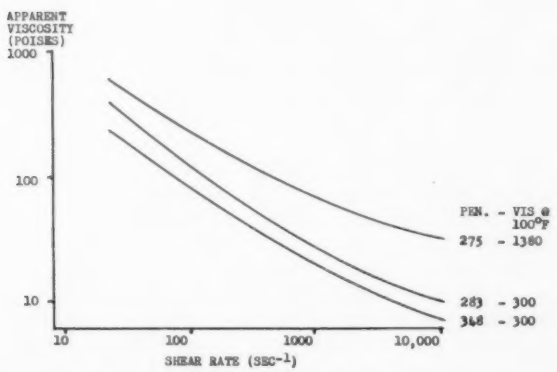

FIGURE 5—Typical apparent viscosity—shear rate curves.

If we assume that the differences are as great as would be found at shear rates of 100 sec.$^{-1}$ vs. 1000 sec.$^{-1}$ or 10,000 sec.$^{-1}$, viscosity values taken from the above curves are revealing.

	Apparent viscosities (poises) at shear rates (sec^{-1}) of		
	100	1000	10,000
Penetration			
275	205	62	28
283	120	25	10
348	69	20	7

FIGURE 6.

It is apparent that in a mill (under conditions of high shear), viscosity is low even though in a kettle (low shear) viscosity may be high. Furthermore, even heavy greases are fairly fluid at high shear (mill) conditions. Therefore the visual observation that a grease seems heavy does not relate to conditions in the mill.

In our operation, the grease mill or supplemental high-shear agitator has been found extremely useful on greases that are inherently fibrous. Its effectiveness is lower with calcium, aluminum, or Bentone greases, although modifications can be visualized which should improve results with these too. The mill is being used extensively on sodium and lithium greases, as well as on silica greases.

In order to give examples of what the mill does, it was necessary to make deliberate "before and after" batches in the lab. These do not show the mill to best advantage, and in some cases plant experience too must be cited. One clear-cut instance involves lithium-12-hydroxy stearate grease, whose appearance, yield, and performance characteristics were improved by milling properly. Eight per cent of this soap and an oil of 85 SUV @ 210°F were heated to about 400°F, then kettle cooled. Product drawn without milling had a penetration of 310, passed a wheel bearing test at 220°F spindle, but slumped out of the hub at 265°F spindle, although throwout was an acceptable 0.6g. When this grease was milled for one hour, it became visibly smoother, but penetration (307) and performance at 220°F and 265°F (0.5g throwout at 265°F spindle) were almost identical. The batch was repeated, but milling was carried out during the entire cooling cycle. Penetration dropped to 291, and the grease was firm in the hub of the wheel bearing tester even at 265°F spindle, although throwout was now 1.2g.

In another type of formulation, milling has attained different objectives when handled in different ways. Thus a 12 per cent Lithium soap grease was made from the same oil as before, but conventional fatty materials. Dehydration was carried out at 320°F; then the grease was cooled while the remainder of the oil was added.

Unmilled grease had a coarse, grainy appearance, a penetration of 335. The wheel bearing test at 265°F spindle gave 14.lg throwout, and almost half the remaining grease slumped out of the hub. When the grease was subjected to milling for 1 hour, penetration improved to 323; appearance was now smooth and glossy, showing moderate fiber. Throwout at 265°F spindle was 2.5g, with only a bit of slumping of grease within the hub. This product was now commercially acceptable. In production this formula was used but milling time increased and processing modified to shorten time cycles. Further improvements were found in yield (less than 11 per cent soap gave a penetration of 285), and performance on the wheel bearing tester (practically no slump, and only 0.5g throwout).

In making a soda soap bearing lubricant, texture, performance, and yield were improved. Using 12 per cent soap, and an oil of 300 @ 100°F SUV, the unmilled grease gave 348 penetration and a poor wheel bearing run at 225°F spindle, with grease and oil slumping out to the pan, and 3 g. of throwout. This batch was milled for 1 hour. Penetration dropped to 321, and no slump or throwout was observed in the wheel bearing test. It should be noted that more soap would have been required to bring the unmilled grease within the No. 1 range, whereas the milled grease was well within range.

When time saving is desired, it can be achieved. Thus a soda soap chassis lubricant can be made by carrying out the reaction and the dehydration in the presence of a considerable portion of the total oil. Cold water is started through the jacket, the mill is turned on, and oil is poured in as fast as the piping allows. There is no heavy stage in the manufacture of the grease. The fairly fluid kettle contents turn into grease late in the processing, and a whole batch may be produced in considerably less than one working day. Remember—this is in conventional cooking and kettle equipment, with 100 to 125 psi steam pressure. With other heating equipment, further drastic changes in techniques and in results, are possible.

As a corollary but extremely important advantage, the use of milling as a part of the standard procedures has cut batch failures on sensitive products to an almost negligible level.

Conclusion

It is hoped that the reason for the strange title of this paper is now apparent. The philosophy here derived and illustrated has been to use a milling device to supplement kettle stirring during regular processing cycles. The mill then serves as a supplementary high-shear agitator. The particular mill with which experience has been gained is described.

Many advantages have been realized. Obsolescence of conventional kettles has been retarded. Objectives such as saving time, decreasing batch failures, improving performance on given test devices, increasing smoothness, etc. may be set. In some cases milling has made it easier to meet such objectives. In other cases, only with the mill have the ends been accomplished.

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Non-Soap Lubricating Greases

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Abstract

Soap-thickened greases have been improved continuously, but now other thickeners are sharing the burden of meeting modern needs. The new thickeners must have the combined properties of oleophilic nature, fine particle size, and stability.

The required properties have been attained by selecting suitable organic compounds and by coating inorganic particles to render them oleophilic. Such classes of organic compounds as aryl ureas and indanthrenes possess the required properties. When long-chain organic compounds are adsorbed or reacted on the surface of inorganic particles, stability is determined by the coating.

The new thickeners may be used with conventional oils to produce excellent multi-purpose greases. With synthetic oils they may be used for as long as 600 hours at 450°F without relubrication. Already consideration is being given to thickeners, oils, and test devices for service at 700°F.

Introduction

Lubricating greases consist of liquid lubricants thickened to semisolid structure by minor amounts of dispersed solids. Service conditions dictate the choice of both ingredients; the liquid may be a petroleum oil or a synthetic oil like esters or silicones; the thickener may be a soap or other dispersible solids. During the past decade, three factors accelerated the development of thickeners other than soap: the capabilities of soaps have been rather thoroughly exploited; extensive knowledge has been gained on the structure of grease and on the role of the thickener; and increasingly severe requirements are being imposed on greases, particularly those for military uses.

Soap greases had kept pace with changing needs to an amazing degree. Improvements were made in both the saponifiable fat and the metal cation from which the soaps are made.[1] The use of distilled and hydrogenated fatty acids improved the stability of the soap. New or better mechanical properties were obtained with thickeners made from fatty acids of selected composition; notable examples are high-molecular-weight fish acids and hydroxy stearic acid from castor oil. Soaps of barium, strontium, or lithium combined the separate advantages of the older calcium and sodium soaps; by 1958, lithium greases had captured 28 per cent of the U. S. market. Furthermore, new manufacturing methods and equipment produced useful changes in grease properties. Nevertheless, soap greases could not be expected to meet every need, and it was necessary to seek other thickeners.

The development of other grease thickeners was hastened by new knowledge of the physical nature of grease. Of primary importance were studies that demonstrated the particulate nature of the thickener. Because the oil can be removed with solvents, and even replaced without destroying the structure, the thickener must form a discrete phase.[2] During flow, greases decrease in viscosity because thickener particles orient, as can be shown by polarized light.[3] Finally, the electron microscope yielded direct evidence of the

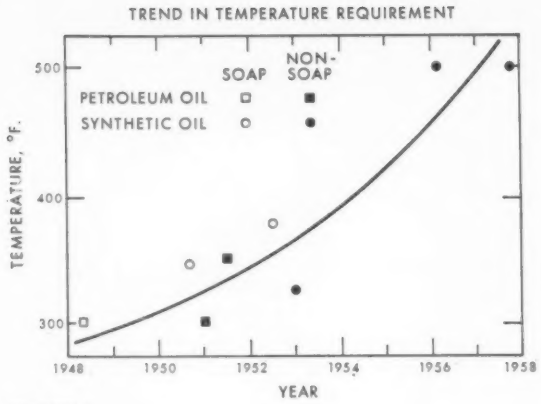

FIGURE 1.

particle size and shape.[4] Thus, we have learned that oils can be thickened to semisolid structure by any randomly dispersed, finely divided, particulate solid. Whether or not the result is a grease depends on other properties.

Particles that thicken by sheer volume give semisolids that have the properties of a paste rather than a grease. The difference seems to involve forces of attraction among the particles and with the oil, a characteristic called "oleophilic nature." Physical bonding of submicroscopic particles to form fibers or of fiber intersections to form weak networks may explain thickening by extremely fine isometric particles and the apparent healing of such networks after shearing.[5]

Greases have been needed to meet more rigorous requirements in the age of supersonic aircraft and nuclear power. Needed resistance to high temperature and to radiation are fundamental reasons for turning to thickeners other than soap. For example, Figure 1 shows that the temperature requirement in U. S. Government specifications for military greases has risen from 300 to 500°F in about ten years. The more recent specifications require non-soap thickeners and, in a few cases, synthetic oils, which preclude the use of some thickeners. Additional requirements that restrict the composition of thickener include greater resistance to oxidation, corrosion, and radiation; ability to run longer in high-speed bearings; and lower apparent viscosity at – 100°F.

The properties required in a good thickener may be deduced from our knowledge of grease structure and the new performance needs. It must exist as a separate, chemically inert phase, yet provide interaction with such a wide variety of fluids as petroleum oils, esters, and silicones. It must disperse into particles in the range of 0.01 to 20 microns. It must maintain these conditions during storage, under mechanical action, and throughout much of the temperature range of – 100 to 500°F, even in the presence of water.

Nature and Properties of Thickeners

Many compounds have been studied as grease thickeners. The chemical and physical structures of some prominent types are shown in Figure 2. In chemical structure, they range from linear compounds that look like soaps to complicated ring structures that do not. Some are entirely organic in nature; others are mostly inorganic. The physical structure also varies widely. Several have the long twisted fibrous form characteristic of soaps. One consists of needles, another of platelets, and still others of irregular spheres. This variety indicates that many approaches have been used to obtain three prime properties: oleophilic nature, particle size, and thermal and chemical stability. Often one or two are intrinsic properties of the starting material. The others must be built into the finished thickener.

Oleophilic Nature

Thickeners tend to be oleophilic if their chemical structure resembles that of the oil. Such character can be built into thickeners in two ways. Inorganic particles can be coated with an oleophilic layer by chemical reactions or by physical means. Oleophilic groups can be added to organic molecules. In both cases, the long hydrocarbon chain characteristic of soap is usually used.

Coated clay and silica are examples of inorganic particles rendered oleophilic by chemical reactions. In coated clay, sodium atoms on the surface of minute clay particles have been replaced by ammonium cations that carry the long hydrocarbon chain.[6] Covering about 80 per cent of the surface alters completely the original nature of the clay and yields an oleophilic thickener. By a different reaction – esterification with a long-chain alcohol–silica has been coated with an organic layer.[7]

Surface-active agents can provide an oleophilic surface coating by physical means. Fine particles of pyrogenic silica, for example, can be coated during the grease-making process by adding long-chain amines in the oil.[8]

Some oleophilic organic thickeners can be found in nature, but most of them must be synthesized. Readily available indanthrenes[9] and phthalocyanines[10] are directly suitable for silicone oils. The terephthalamate is built up from dimethyl terephthalate by reaction with long-chain amines,[11] and the aryl ureas[12] are formed by a reaction of isocyanates and amines. Many other organic compounds that have the appropriate oleophilic nature for thickening cannot be used because they do not have other properties of a good thickener.

Particle Size

Such important grease properties as consistency, oil leakage, and mechanical stability depend largely on thickener-particle size.[13] If the grease is made by simply

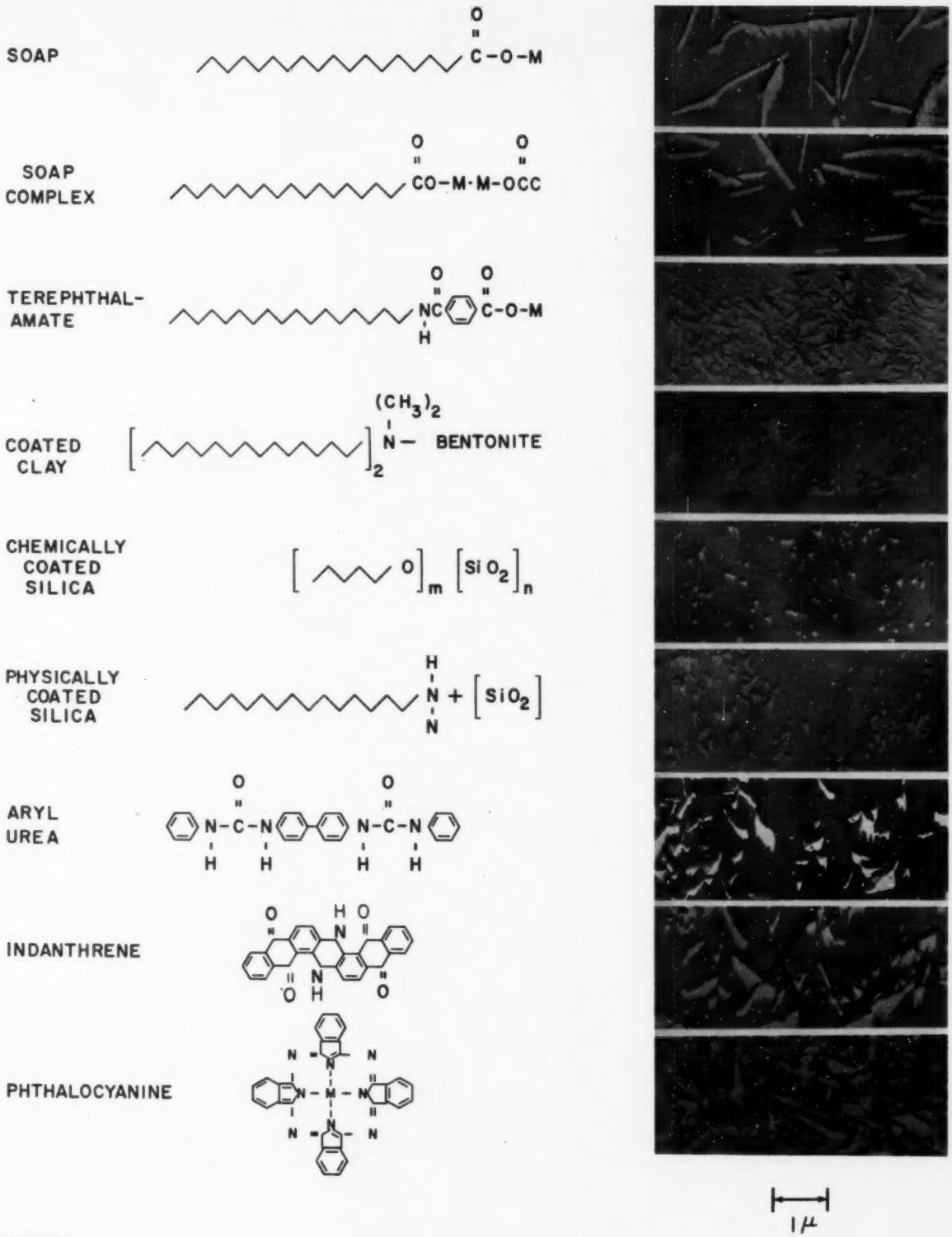
SOAP
C-O-M
SOAP COMPLEX
CO-M-M-OCC
TEREPHTHAL-AMATE
NC
C-O-M
COATED CLAY
(CH3)2
N-
BENTONITE
2
CHEMICALLY COATED SILICA
O
m
SiO2
n
PHYSICALLY COATED SILICA
H
N
N
+
SiO2
ARYL UREA
N-C-N
N-C-N
INDANTHRENE
PHTHALOCYANINE
M
1μ

FIGURE 2.

mixing a preformed thickener and oil, particle size can be easily controlled in advance. However, most greases have long been made by generating the thickener in the presence of the oil; here, control of particle size is much more difficult.

Typical of the preformed thickener are clays, indanthrenes, silicas, and aryl ureas. The desired particle sizes are usually obtained by precipitation from solvents under carefully controlled conditions or by reaction in the vapor phase under controlled air flow and temperature. However, for convenience in handling, they are usually made available in agglomerated form; after combination with the oil, the particles are reduced to ultimate size by thermal, mechanical, or solvent action.

In the past, much of the art connected with grease making was devoted to generating, in the oil, thickener particles of the proper size range. Particle size must be controlled by solubilities and concentrations of both the raw materials and the precipitated thickener particles. Reaction time and reaction rate are also critical. Typical reactions leading to non-soap thickeners are saponification to produce the terephthalamate and amine-isocyanate reactions that lead to the aryl ureas.

Whichever route is followed, the usual final processing through a colloid mill has little effect on particle size. It primarily serves to break up agglomerates or distribute the thickener more uniformly through the grease. Particles differ widely in size, as shown in Table I. Although average longest dimensions obtained by measuring on electron micrographs are reported, of equal importance is the particle-size distribution in a given batch. Average particle dimensions also vary within each class of non-soap thickeners, but not as widely as the 0.1 to 50 μ typical of soaps.

TABLE I

Size of Thickener Particles
(Average Length, Microns)

Preformed	
Bentone	0.05
Estersil	0.01
Aryl Urea	0.7
Phthalocyanine	0.2
Generated in Oil	
Terephthalamate	2.0
Aryl Urea	0.5

Stability

Most aspects of thickener stability are so closely related to service conditions as to require tests on the finished grease. Examples are tests for dropping point, oxygen adsorption, water resistance, and resistance to corrosion of copper and iron.[14] Although these grease properties can often be improved with additives, stability against high temperatures, chemical reactivity, and radiation must depend largely on the nature of the thickener.

Obviously, when subjected to high temperatures, good thickeners must not melt. Moreover, they must not undergo such physical changes as sublimation or impart low dropping point to the grease. Some compounds, melting at high temperatures, usually polar molecules of less than 150 molecular weight, sublime at temperatures far below their melting points. The examples in Figure 2 are high enough in molecular weight to avoid this difficulty. Aliphatic thickeners are most stable when the long chain contains no double bonds. Aromatic molecules have better stability because of resonance. High dropping points can be obtained with thickeners of high melting point. However, the dropping point is often lower than the melting point because temperature affects the oleophilic nature of the thickener and causes oil and thickener to separate. Although all of the thickeners in Figure 2 have dropping points lower than their melting points, their dropping points are higher than the useful temperatures of the oils in which they are used.

Thickeners must not be chemically reactive. Furthermore, they should not contain an excess of starting material that would react with bearing materials or grease additives. Any deterioration should not yield corrosive or abrasive products. Aryl ureas are an example of thickeners that do not produce troublesome residues. On exposure to extreme temperatures, any breakdown yields only the starting materials, which will evaporate.

When greases are used under conditions that require resistance to nuclear radiation, both the thickener and oil must be carefully selected. Aromatic thickeners are more resistant than others, the terephthalamate being a good example. Indanthrenes and aryl ureas are also satisfactory. Tests reveal that the total radiant energy absorbed is more significant than the kind of radiation.

Use of Non-Soap Thickeners

Pursuing these principles to gain desired properties, manufacturers have produced more than one hundred different non-soap greases. Although non-soap greases now account for less than 10 per cent of the U. S. market, they are doing lubrication jobs not possible ten years ago. They are usually used either in multi-purpose greases made with petroleum oil or in special high-temperature greases made with synthetic oil. The significance of the terms "multi-purpose" and "high-temperature" is continually changing to meet new demands and developments, but the current temperature ranges are 0 to 300°F and –65 to 500°F, respectively.

For multi-purpose greases, the generally improved properties of non-soap thickeners make them ideal. Preformed clay, silica, and urea varieties that cost little more than soaps are available. The melting points

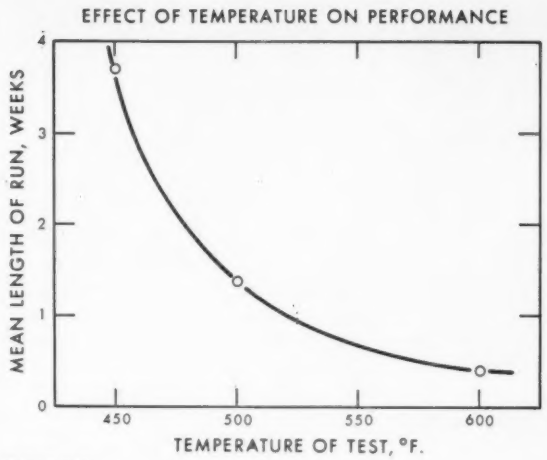

FIGURE 3.

of these thickeners are much higher than the normal service temperature determined by the petroleum oil and offer a safety factor in cases of temporary temperature rise. Grease manufacturing is simple because they are nearly all available preformed. They are readily dispersed by milling in an oil slurry, with or without the assistance of heat or solvents.

High-temperature greases are a more-specialized field, the requirements of which tax the performance of both oil and thickener. Because the temperature range requires esters, silicones, or other expensive oils, costlier thickeners can be justified. As shown in Figure 3, silicone greases made with such thickeners as urea, indanthrenes, or phthalocyanines extend relubrication intervals to beyond 500 hours in the CRC (Coordinating Research Council) L-35 ball-bearing test, at 450°F. If the temperature is raised another 50 or 150 degrees, the interval is considerably reduced. The limiting factor is usually thickener stability, rather than melting point.

Conclusion

To date, the development of thickeners has kept pace with the increasing demands being made of grease lubrication. However, the trend toward severer demands is continuing. In the multi-purpose range, even better thickeners at lower cost will increase the amount of grease made from non-soap thickeners. In the high-temperature range, the next target will likely be 700°F, and cooperative development of 700°F tests is nearing completion. Already oils are available for this temperature if air is excluded.

In further development of thickeners we must not forget that the purpose of grease is to lubricate. Additives to promote lubrication under the wide ranges of temperature that multi-purpose and high-temperature greases must encompass are simply not available. Some of the newer greases lack the needed lubricity, and this feature may have to be built into the thickener. Only non-soap greases could meet such unusual demands.

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About the Author

L. C. Brunstrum *has been a member of the research department of the Standard Oil company (Indiana) since he received his BS degree in chemical engineering from Armour Institute of Technology in* 1929. *He is currently the section leader in charge of research on greases and industrial lubricants. A frequent contributor to the* NLGI Spokesman, *he was appointed chairman of the Technical Committee at the* 1959 *annual meeting. In* 1958, *he was the seventh man to be honored by the "Award of Achievement," after five years as Technical Committee vice-chairman.*

Literature and Patent Abstracts

Composition

Lubricating Greases Thickened with Alizarin Lakes

Lubricating greases, in which the thickener consists of 15 to 35 weight per cent of alizarin lakes, are described by Lyons and Odell in U.S. Patent 2,936,285, assigned to Texaco Inc. The suggested lake is obtained by boiling a water solution containing alizarin and aluminum hydrate in a mol ratio of from 1 to 2 to about 1 to 12 together with at least about 0.5 mol of water-soluble calcium salt per mol of alizarin.

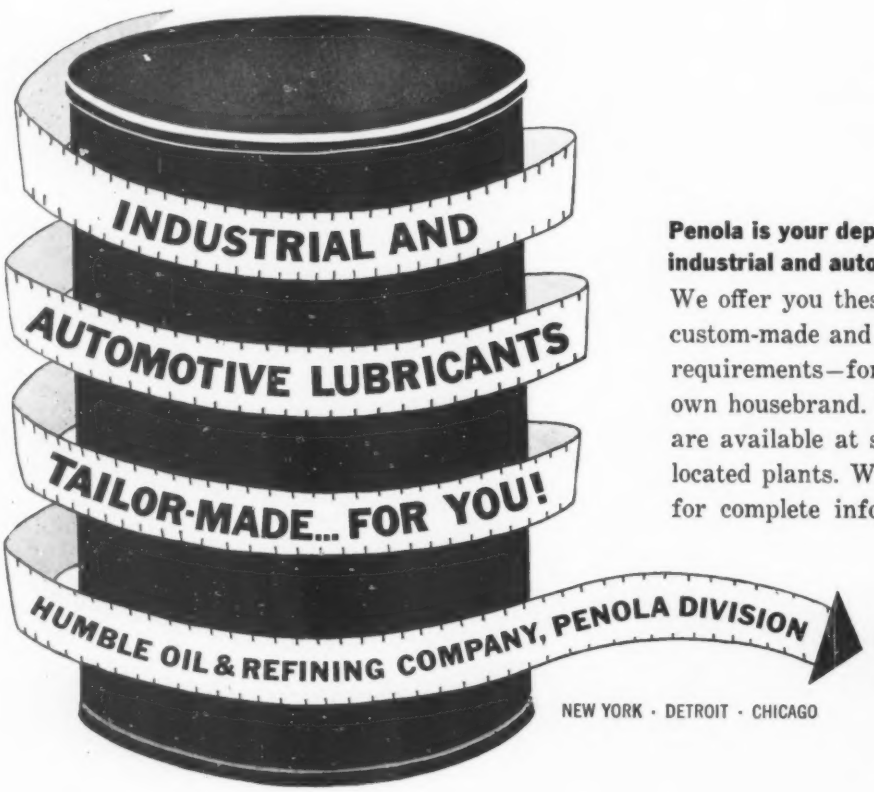
Preparation of the grease consists of mixing and/or milling and heating. For example, 30 grams of alizarin lake and 70 grams of lubricating oil were mixed at room temperature and given two passes through a Premier colloid mill set at 0.002 inch clearance.

A smooth, buttery red lubricating grease resulted having a dropping point above 500°F. The product had a worked penetration of 321 which changed to 330 after 100,000 strokes in a Grease Worker. In a bomb oxidation test a pressure drop of three pounds occurred in 100 hours. When subjected to a dynamic water resistant test, 2.5 per cent loss occurred.

Complex Calcium Base Lubricating Greases Containing Polyethylene

In U.S. Patent 2,935,477, assigned to Esso Research and Engineering Co., Morway describes dispersions of calcium acetate in lubricating fluids which are stabilized by the presence of 0.5 to 10 per cent of polyethylene. A minor amount of calcium salt of an inorganic acid, such as calcium nitrate, may also be included in the dispersion as can some fine silica.

The polyethylene, which preferably has a molecular weight of 10,000 to 22,000, is dispersed in the oil by mixing and heating to 300 to 450°F after which the mixture is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cooled before grease formation.

For example, a grease was prepared from the following ingredients, all in weight per cents: glacial acetic acid 20, hydrated lime 13.4, polyethylene resin of 18,000 molecular weight 3.3 and lubricating oil having a viscosity of 80 SUS at 210°F 63.3.

The polyethylene was dispersed in the oil with mixing while heating to 300°F for two hours. After this dispersion was cooled to room temperature, the lime was added and mixed to a smooth, nonlumpy consistency. Next, the acetic acid was added while stirring. A solid grease formed immediately and the temperature rose to about 200°F. Agitation was continued until this temperature subsided.

After the resulting lubricating grease was cooled to room temperature a product, with a smooth texture and penetrations of 275 unworked, 320 worked and 355 after 100,000 strokes, was obtained. When dehydrated the unworked penetration was 300, and upon heating to 400°F, while there was a tendency to thin out, no agglomeration of calcium acetate crystals occurred.

This lubricating grease had no dropping point and on a Timken E.P. Tester stood a load of 40 pounds with a fairly wide scar. After the addition of 0.5 per cent phenyl alpha naphthylamine to the product, it was 336 hours before a five pound pressure drop occurred in a bomb oxidation test.

Preparation of a similar lubricant is described where 15.1 per cent of lime was used followed by a mixture of 14 per cent glacial acetic acid and 8.6 per cent of 70 per cent nitric acid. This gave a product with an unworked penetration of 200, which changed to 275 after 60 strokes and 285 after 100,000 strokes. The only other characteristics given are a smooth texture, brownish yellow color and insoluble in boiling water.

Lubricating Greases Consisting of Thickened Fluorochloro Polymers

Lubricating fluids having high

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load-carrying capacity consist of up to 20 weight per cent of a liquid open chain telomer of trifluorochloroethylene mixed with other lubricating fluids. In U.S. Patent 2,927,893, assigned to Minnesota Mining and Manufacturing Co., Neunherz claims silicone fluids as the diluents. In U.S. Patent 2,927,-894 by the same author, a diester, such as di-2-ethylhexyl sebacate, is the diluent used. In U.S. Patent 2,927,895 mineral oil is used as the diluent.

Thickening agents can be added to any of the above fluid mixtures so that lubricating greases can be formed which have load-carrying ability greater than products without the fluorochloro polymers present. The gelling agents suggested include metal salts of organic acids or inorganic materials such as bentonites or fine silicas.

The preferred metal salts for the above purpose are those of organic perfluorochlorocarboxylic acids. Such acids may be prepared by the potassium permanganate oxidation of a thermally cracked trifluorochloroethylene polymer or by hydrolysis with fuming sulfuric acid of sulfuryl halide telomers of trifluorochloroethylene.

An example of the preparation of a lubricating grease useful as an aircraft turbine lubricant consisted of mixing 20 grams of a sulfuryl chloride-trifluorochloroethylene, 70 grams of di-2-ethylhexyl sebacate and 10 grams of Estersil-GT. No characteristics of the finished lubricant were given.

Heavy-Duty Gear Lubricant

Non-fluid lubricants suitable for use in tractor gear boxes of diesel locomotives are described by Morway and Ball in U. S. Patent 2,937,-144, assigned to Esso Research and Engineering Co. The lubricant, of grease consistency, consists of 10 to 30 per cent of low cold test oil and 65 to 82 per cent of a non-asphaltic resin obtained by pentane precipitation of Mid-Continent or Pennsylvania oils, the whole thickened with a dehydrated sodium soap-salt complex made from rapeseed oil.

A typical lubricant was made from 8 per cent rapeseed oil, 1.44 per cent sodium hydroxide, 0.25 per cent sodium sulfonate, 0.25 per cent phenyl alpha naphthylamine, 0.13 per cent of the condensation product of 1 mol of propylene diamine and 2 mols. of salicylaldehyde, 14.93 per cent of an oil having a viscosity of 55 SUS at 210°F, and 75 per cent of a resin extracted from Pennsylvania oil and having a viscosity of 14,000 SUS at 210°F.

The rapeseed oil, sodium sulfonate and 55 per cent of the oil were mixed and heated to 150°F where the sodium hydroxide as a 40 per cent water solution was added. The temperature of the mass was then

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raised over a four hour period to 350°F followed by heating for another two hours while the temperature was raised to 500°F. The remainder of the oil was then added and the mixture cooled to 250°F over a period of five hours. At this point the inhibitors were added and the mixture was cooled to 200°F before passage through a Gaulin homogenizer at 5,000 psi. The resin can be blended in either before or after the homogenization.

The finished lubricant had an unworked penetration of 310 and a worked penetration of 320. The dropping point was 400°F and the viscosity 3,000 SUS at 210°F. Satisfactory service was obtained with the lubricant for over a year in locomotive gear boxes.

Tacky Lubricating Greases

According to Rene Hatton (see French Patent 1,150,063 taken out by Esso Standard Societe anon. francaise) if a mixture of 0.4 to 0.6 per cent, based on the total weight of the lubricant, of polyisobutylene and 0.01 to 0.05 per cent ammoniacal latex is added to a lubricating grease at about 100°C and 30 minutes before the completion of cooking the length of the fibers are increased. Agitation during this period should be slow.

The comparative length of the fibers formed was determined by placing the lubricating grease between two metal plates, one of which was dished, and drawing the plates apart.

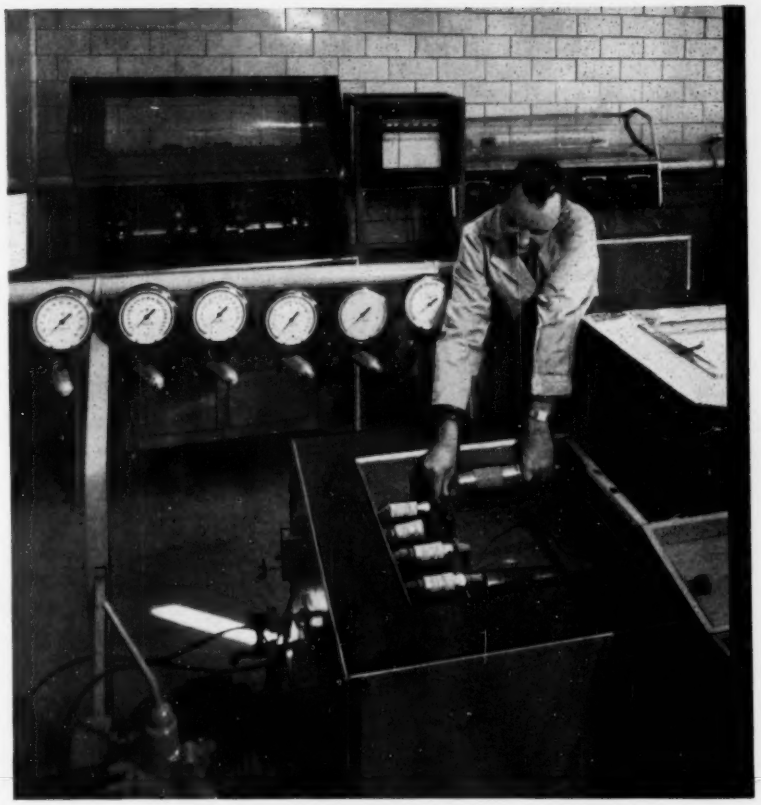
High Temperature Lubricating Grease

In U.S.S.R. Patent 123,647, Sobolevskii and co-workers describe lubricating greases made by thickening silicone fluids, of the phenylmethyl type, with finely divided poly (tetrafluoroethylene). Ten to 70 parts of the filler is used to 90 to 30 parts of the fluid.

Processing

Lithium-Calcium Base Lubricating Greases

Preparation of lithium-calcium base lubricating greases below the melting point of the soaps is described by German Patent 1,018,-



. . . How Greases Behave at -65°F is examined by chemist in International Lubricant's New Research Laboratory

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180, issued to Esso Research and Engineering Co. The preferred ratio of lithium soap to calcium soap is two to eight of the former to one of the latter. A mixture of long chain fatty acids in a portion of the total oil is mixed with the alkalies and the mass held at 105 to 160°C until dehydrated after which further oil is added and the mixture is milled. The dehydration may take place in vacuum if desired.

For example, 12.6 parts of tallow fatty acids were mixed with 42.6 parts of lubricating oil and, after heating to 74°C, 0.71 parts of hydrated lime was added followed by 1.52 parts of lithium hydroxide monohydrate as a 10 per cent solution. At this point the temperature was 99°C which was gradually increased to 142.5°C. Additional oil (42.57 parts) was added as the mass stiffened over a period of 55 minutes and while the temperature was held above 121°C. After stirred cooling, the mixture was passed through a Morehouse mill set at 0.025 mm. clearance. Electron microscope examination of the lubricant showed the thickener fibers to be uniform and thin with a length of about 10 microns.

Additives

Stabilizer for Alkali Metal Soap Lubricating Greases

Sodium base lubricating greases are stabilized against oxidation or decomposition by mechanical treatment or high temperature if 0.05 to 5 per cent of a suggested additive is included in the composition. This additive, which is suggested by Perrus, Signouret and Tirtiaux in French Patent 1,152,343 and credited to Esso Standard Societe anon. francaise, is formed by reacting an alkyl phenol with one to four moles of an alkylene oxide and treating the resulting product with formaldehyde and ammonia.

Application

Bus and Truck Lubrication

The May, 1960 issue of *Lubrication* (Texaco Inc.) is devoted to the above subject and two statements are of particular interest to SPOKESMAN readers. These are: "An increasing number of truck operators are now spending as much as 35 cents a pound for premium grease when they could get an ordinary grease for as little as 10 cents" and "Chassis lubrication is more important than ever before due to closer tolerances, heavier vehicle weights and higher road speeds."

A simplified lubrication plan recommends Multipurpose Grease No. 2 for chassis parts, universals and wheel bearings. However, mention is made of the fact that the term "multipurpose" may be applied to a variety of products and therefore the user should consider the integrity and reputation of the supplier when choosing the lubricant.

Tests

Evaluation of Adhesiveness of Lubricating Greases

Fayerman in Zavodskaya laboratoriya (USSR) Vol. 25, No. 11, p 1396 (1959) describes a test for determining the adhesiveness of lubri-

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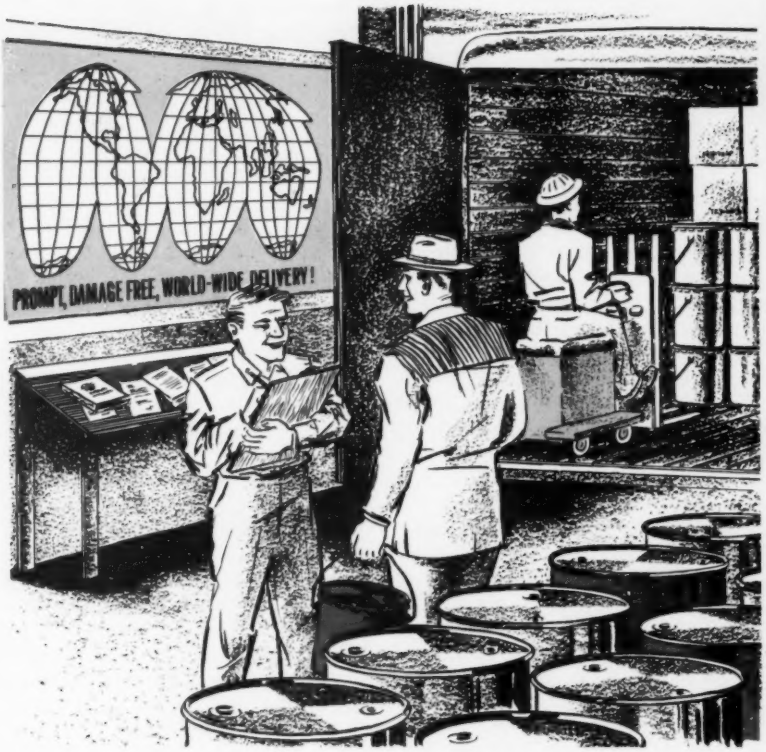

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cating greases. The method is patterned after that described by Finlayson and McCarthy in NLGI SPOKESMAN v. 14, No. 2, p. 13 (1950).

A smooth metal disk, 40 mm. in diameter, is attached in a horizontal position to a perpendicular motor shaft. A layer of the lubricant 0.2 mm thick is applied to the disk and the whole weighed to 0.002 g. After remounting the metal disk on the shaft, the motor is run for three minutes at a certain speed. If the weight of the lubricant has remained the same, the test is repeated at a higher speed of rotation. The adhesion of the lubricating grease is calculated from the difference in weight before and after the test. A guard on the apparatus protects against spattering.

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Characteristics

Frictional Resistance of a Radially-Loaded Journal Bearing with Grease Lubrication

Rajat K. Chakrabarti and Ralph J. Harker, *Lubrication Engineering* v. 16, pp 274-280, 290 (1960).

These investigators, using certain lithium base lubricating greases, found that the friction torque in a grease-lubricated sleeve bearing could be expressed by an equation involving the load and speed. However, it is quite evident that the characteristics of the oil component of the lubricant have a greater influence on torque than does the percentage of soap thickener.

Two series of lubricating greases were used in the experiments in which the samples contained 4, 8, 12 and 16 per cent of lithium soap derived from a mixture of 60 parts of hydrogenated tallow glycerides and 40 parts of hydrogenated castor oil. The fluids used in the greases were blends of high V.I. Bright Stock, intermediate V.I. Bright Stock and 85 viscosity neutral blended to viscosities of 98.3 and 1103 SUS at 100°F.

Tests were conducted at 90°F in a test journal driven at speeds of 400 to 3,600 rpm. The test bearing was bronze bushed bored to 1.002 inch and with a length of 1.00 inch. The radial clearance was 0.001 inch and no seals were provided.

The authors conclude that "the frictional torque in a grease-lubricated sleeve bearing increases with increasing speed and with increasing load."

Protection Against Atmospheric Corrosion by Lubricating Greases

Martynov in Trudy Vesoyuz. Nauch.-Issledovatel. Inst. po Pererabotke Nefti i Gaza i Poluchen. Zhidkogo Topliva, No. 7, pp 414-433, 1958, describes tests to determine the penetration of atmospheric moisture and oxygen through layers of lubricating grease.

For the purpose, a number of Soviet industrial greases and also petrolatum were used. The penetration of moisture varied with both the specific product and the thickness of the lubricant layer. Thus, a lubricating grease named "Cyatim-221," which we presume to be made from a low viscosity oil, had a moisture penetrability 10 to 15 times greater than a gun grease. Table 1 shows water absorption for the former product when subjected to different relative humidities at 20°C.

The general conclusion from this investigation was that the lubricating greases tested were not capable of protecting metals against corrosion due to atmospheric moisture.

Table 1

Relative Humidity Per Cent	*Per Cent Water Vapor Absorbed*	
	Two Hours	*Nine Hours*
100	2.5	5.23
90	1.7	2.68
80	0.57	0.93
60	0.0	0.0
40	0.0	0.0
20	0.0	0.01
10	0.02	0.01

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People in the Industry

Named Vice-President of American Can Division

Appointment of Richard H. McCarthy, Jr., as vice-president in charge of sales for the Bradley-Sun Division, American Can Co., has been announced by C. L. Alexander, vice-president in charge of division operations.

McCarthy, who has been director of sales for the past fifteen months, will be responsible for the sale of collapsible metal and plastic tubes, plastic squeeze bottles, aluminum impact extrusions and other products made by the division.

He joined Sun Tube corporation, a predecessor company, as a product manager in sales in 1955, after sales experience in other fields. After serving as a sales manager, McCarthy transferred to production work as manager of the division's Washington, N. J., plant.

Resigns Battenfeld Post

Mr. George W. Krause has resigned the position of vice-president of Battenfeld Grease and Oil Corporation (K. C.), and is temporarily affiliated with the Penn-Central company of Kansas City, Kansas, in a consulting and advisory capacity.

Penn-Central is an oil compounding company, where Mr. Krause's services will be utilized to assist in expanding the plant facilities and services.

Smith and Wood Promoted at Climax

Elwin E. Smith has been appointed general sales manager of Climax Molybdenum Co., a division of American Metal Climax, Inc., according to Reuel E. Warriner, division vice-president of sales. He succeeds Lars Ekholm, who has been advanced to vice-president of eastern operations.

Mr. Smith has been manager of chemical sales for the past two years. He joined Climax in 1955 as manager of lubricant development, after more than ten years in the petroleum and chemical industries. He is a member of the American Chemical Society, American Society of Lubrication Engineers, American Petroleum Institute, National Lubricating Grease Institute and the Society of Automotive Engineers.

Kenneth B. Wood, Jr., has been named manager of the chemical division, succeeding Mr. Smith. Mr. Wood has been manager of lubricant development. He joined the company in 1956, after serving as regional manager of lubricant sales for Cities Service Oil Co. He is a member of the American Society of Lubrication Engineers, National Lubricating Grease Institute and Independent Oil Compounders Association.

American Potash Names Kolyer

William W. Kolyer has been appointed assistant district manager of American Potash & Chemical corporation's eastern market development office, according to Dr. Howard E. Kremers, district manager.

Kolyer will assist Kremers in the developmental activities assigned to the New York office.

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D. Aden Smith Retires from Valvoline

D. Aden Smith, chief chemist, grease division of the Valvoline Oil company, Division of Ashland Oil & Refining company, retired as of July 1, 1960, having supervised the production and development of all Valvoline, as well as the Galena division lubricating greases for the past 30 years.

He is well known in the lubricating grease manufacturing industry, having attended and being the only Valvoline representative to the National Lubricating Grease Institute down through the years, including the initial meeting of the lubricating grease manufacturers held in Chicago in 1934, which eventually resulted in the birth of NLGI.

During the past year, he was under assignment by Valvoline to C. A. Nacional de Grasas Lubricantes as a grease consultant on three separate occasions, necessitating his spending approximately two weeks each time at their plant located in Valencia, Venezuela, S. A. This is an all new and very modern lubricating grease plant which just got into commercial production early this year. It is the only lubricating grease manufacturing plant in Venezuela.

Mr. Smith is presently under contract with the C. A. Nacional de Grasas Lubricantes to continue as their consulting engineer on a part time basis in the United States with occasional visits to their Venezuela plant as required. C. A. Nacional de Grasas Lubricantes holds Active membership in NLGI and has authorized Mr. Smith to attend forthcoming NLGI meetings as their Technical representative.

Vulcan Appoints Jones As Advertising Manager

John H. Jones has been appointed advertising manager of Vulcan-Associated Container companies of Birmingham, Alabama, according to Gordon D. Zuck, president.

Mr. Jones is a graduate of the University of North Carolina with a degree in advertising and journalism. He is a native of Georgia, and for the past ten years has been engaged in advertising and public relations in the Southeast and Midwest. He will maintain his headquarters at the company's Executive Offices in Birmingham.

Ichord Named to New Shell Chemical Post

Robert F. Ichord has been named manager of Shell Chemical company's newly-formed staff administration department.

R. C. McCurdy, president of Shell Chemical, said the new department will provide advisory, liaison and coordinating services on behalf of Shell Chemical's head office and division managements in such matters as senior staff planning, organization, salary administration, and special studies in this general field.

Ichord joined Shell in 1930 in St. Louis. He has held a number of personnel positions of increasing responsibility. Prior to his new appointment, which became effective September 1, he was manager of the organization division in Shell Oil company.

Gulf Research Names C. J. Livingstone

Dr. Blaine B. Wescott, executive vice-president of Gulf Research & Development company, has announced the appointment of C. J. Livingstone as an associate director of research, in charge of product research, development and testing. Mr. Livingstone will direct the activities of product and automotive engineering divisions at the laboratory and Gulf's automotive research office in Detroit, Mich.

A native of Pittsburgh, he joined the Gulf fellowship at Mellon Institute, Pittsburgh, upon graduation

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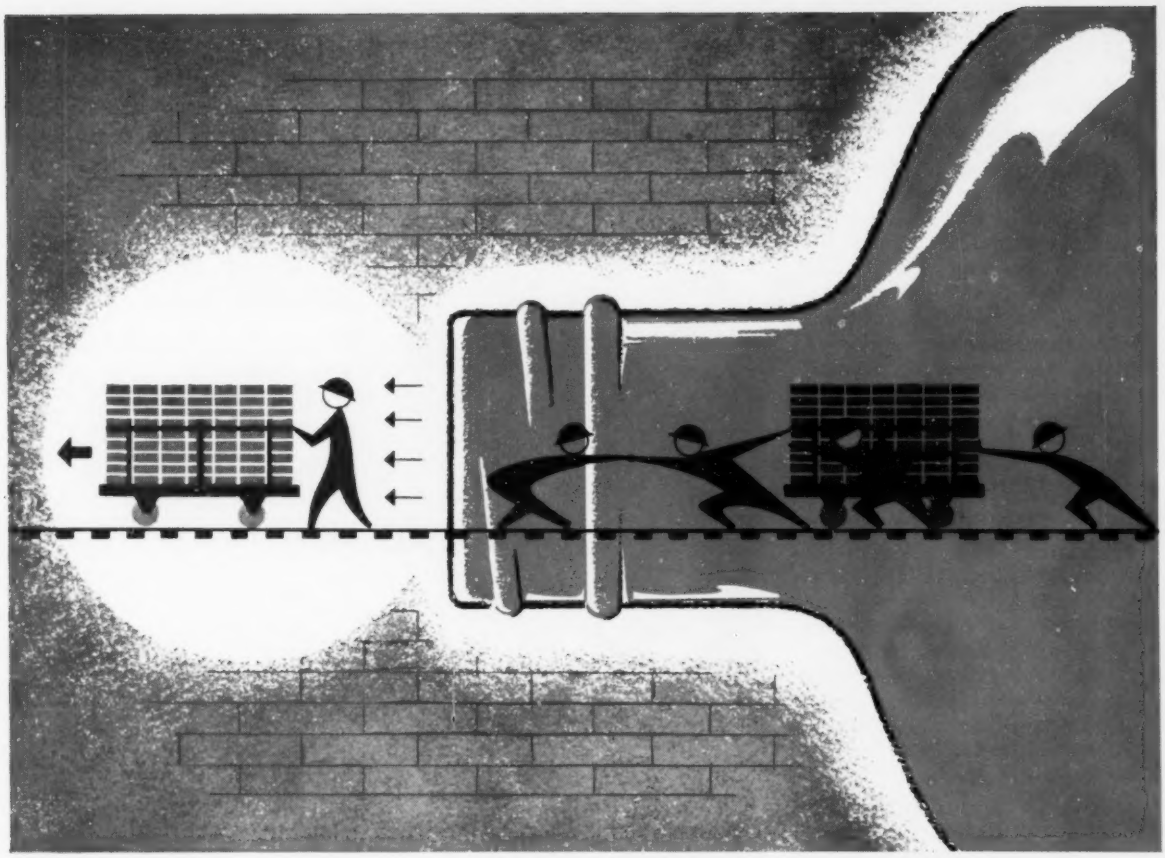

New "hot" grease ends brick-oven bottlenecks

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Ceramic Combustion & Engineering Company, consultants for the Davidson Brick Co., Los Angeles, California, ran into production bottlenecks while using ordinary grease in dryer-car bearings. Oven temperatures (350° to 400° F.) cooked the grease solid . . . stalled the cars loaded with bricks in the dryer. Bearings seized so badly that four men were needed to move each carload.

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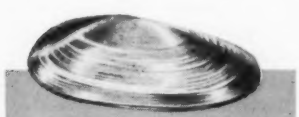

An Interesting Fact! Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here: Darina solenoides.

SHELL DARINA GREASE

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from the University of Pittsburgh in 1924. He was transferred to the Gulf research center in 1940 as chief automotive engineer.

After serving as a commander with the U.S. Navy during World War II, Mr. Livingstone returned to Gulf Research as assistant to the director of research. Three years later, he joined Gulf Oil corporation's domestic marketing as director of product development and in 1954, he was named director of product application, a position he held until his present appointment.

Bel-Ray Names Sales Representative

Bill Sosnow transfers both his '51 B.S. in chemistry from the Philadelphia college of Pharmacy and Science and five years' experience in selling to the field of lubricants, with his recent appointment by the Bel-Ray company, Farmingdale, New Jersey as its Philadelphia sales representative for their long list of special lubricants.

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Technical Director at McCollister Grease & Oil

McCollister Grease and Oil corporation of Omaha has announced that Leonard W. Okon has assumed the duties of technical director.

A graduate of the University of Illinois with a degree in chemical engineering, Okon had five years' experience with the Chek-Chart corporation as a field automotive engineer. More recently, he was employed by Kerr-McGee Oil Industries as manager of sales technical service.

R. B. Gervan Elected To Texas City Board

R. Bruce Gervan, Ithaca, N. Y., has been elected a director of Texas City Refining Co., Texas City, Tex. He succeeds the late Charles N. Silcox, G.L.F. general manager from 1952-1958.

Gervan is secretary of Cooperative G.L.F. Exchange, Inc., major stockholder of the petroleum concern. Other owners are Southern States Cooperative and Pennsylvania Farm Bureau Cooperative association.

Other G.L.F. executives on the Texas City board are William J. Fields, G.L.F. treasurer, and W. Stuart Miller, buyer for the G.L.F. petroleum division.

Changes at American Potash

William W. Young has been appointed southern area regional sales manager for American Potash & Chemical corporation, it was announced by Dr. A. J. Dirksen, general sales manager, eastern.

Young, who will open the company's first regional headquarters at Atlanta in the near future, will have sales and administrative responsibility for the Atlanta and Shreveport district offices.

Niven D. Morgan, Jr., formerly sales representative at Shreveport, replaces Young as district manager at that office.

C. L. Straughan continues as manager of the Atlanta district and will assist Young with regional matters.

Air Force Contract To E. F. Houghton & Co.

The United States Air Force has awarded a new research and development contract to E. F. Houghton & Co., Philadelphia, Pa., for development work leading to new fire-resistant lubricants and fluids to be used in high speed aero-space vehicles where temperatures are too high for conventional fluids.

This contract is under the direction of the nonmetallic materials laboratory, materials central, Wright Air Development division. It represents an extension of the Air Force program to provide materials for efficient performance of new space vehicles.

E. F. Houghton & Co. has pioneered in industrial applications of fire-resistant fluids. W. F. MacDonald, president, states: "We are very pleased to have been awarded this contract, and will apply our experience in specialty lubricants and hydraulic fluids to this further phase of the problem."

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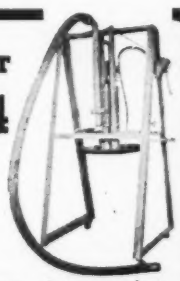

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Industry News

NLGI Member Opens New Plant in Venezuela

THIS view shows the new plant of C. A. Nacional de Grasas Lubricantes during construction. Located at Valencia, Venezuela, it was dedicated last June 11.

With attendance of the ministers of development and mines and hydrocarbons, Drs. Lorenzo Fernandez and Juan Pablo Alfonzo, plus numerous representatives of other government departments, as well as industrial activities in Venezuela, C. A. Nacional de Grasas Lubricantes, on June 11, 1960, inaugurated its industrial plant located at Valencia, Venezuela, S. A.

This new enterprise is the first of its type in Venezuela, designed to produce a wide variety of top quality lubricating greases and lube oils, especially suited for automotive, industrial, agricultural, etc., applications.

The plant representing an investment of more than five million bolivares, wholly subscribed by Venezuelan investors, will be in the position of supplying the whole of the Venezuela market with all types of top quality lubricating greases, lube oils and associated petroleum products. From the technical aspect, Drs. Frank Salas and Ladislao Szikora, technical directors of the enterprise, state that the products to be manufactured by the new plant will fully follow international quality specifications, and to maintain these specifications they have established a very modern laboratory, adequately equipped with the latest type apparatus and testing machines, and staffed with well trained technicians. Capacity of the plant will be 700,000 kilograms per month and, while the lube oil blending facilities are just getting underway, they will be in full operation in the last quarter of this year.

Talks were given by ministers of development and mines and Pro-Venezuela president, Sr. Alejandro Hernandez, pointing out the importance of industrializing Venezuela's prime natural wealth, as well as the valuable contribution made by private capital in the development of this industry in which the national government is vitally interested.

Dr. Julio Sosa Rodriguez, engineer-president of C. A. Nacional de Grasas Lubricantes, made the inaugural address, and after showing visitors the modern facilities of the plant, provided an excellent luncheon and entertainment at a local picnic ground during the afternoon and early evening for all those in attendance.

The company is an Active member of NLGI, with Dr. Ladislao Szikora serving as Company representative and D. A. Smith as Technical representative.

Offers Booklet On Solid Lubricants

The theory and practice of lubrication by solids are the primary subjects in a new booklet just published by the Alpha-Molykote corporation, one of the world's largest manufacturers of molybdenum disulfide lubricants for industry. The booklet discusses boundary friction and the role of solid lubricants to reduce friction and wear under heavy loads and at high temperatures.

The 24-page, four-color booklet describes the major advantages of molybdenum disulfide solid lubricants — low coefficient of friction, natural affinity for adherence to metal surfaces, and pressure resistance beyond the yield point of any metal.

To answer the question of its title "What is Molykote?" the booklet goes on to discuss molybdenum disulfide lubricants, which are available in powder form, as greases, as resin bonded coatings, as dispersions, or in a variety of special forms.

The company's research facilities and activities, both in this country and in Germany, are also described. In conclusion, the booklet discusses the extensive literature which the company has published on the subject of lubrication.

Bulletin 124 is available without cost from the Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

New High-Temperature Lubricant Announced

A new high-temperature lubricant claimed to have excellent thermal and oxidation-corrosion stability has been developed by Metal & Thermit corporation. Called Diphenylbis-*n*-Dodecylsilane, it is a colorless, mobile liquid with good stability and an excellent temperature-viscosity ratio at elevated temperatures. It exhibits no corrosive effects on metal parts, either on storage or when functioning.

Suggested applications include base stock or high-temperature aircraft gas turbine lubricating oil, where thermal stability in 500-700°F range is required; as a hydraulic fluid for actuators in gas turbine aircraft and other equipment operating over a 0-700°F range; as an extremely stable high-temperature heat transfer fluid and as the base stock for lubricating oils and greases where high temperature stability and low vapor pressure are required.

Typical Physical Properties

Physical Form, Colorless, mobile liquid
Molecular Weight, 520.9 g.
% Silicon, 5.39
Melting Point, -40°F
Pour Point, -25°F
Flash Point, 530°F
Density, $d_4^{25°C}$, 0.895
Bulk Density, 7.45 lbs./gal.
Refractive Index, $n_D^{25°C}$, 1.5053
Surface Tension, dynes/cm., 24°D, 41.88

For further information, write Commercial Development Div., Metal & Thermit Corp., 100 Park Ave., New York 17, N. Y.

Develops New Self-Emulsifiable Wax

A new, self-emulsifiable wax, with a melting point of 120°F, has been developed after two years of research by Werner G. Smith, Inc., of Cleveland, Ohio. Known as Emulsifiable Hywax-122, the new product is composed essentially of myristyl, cetyl and stearyl alcohol esters of myristic, palmitic and stearic acids with chemically bound emulsifier. Previously, these esters were quite difficult to emulsify and required a high percentage of emulsifiers. Now, stable emusions are easily formed by simply adding warm water to the melted wax and agitating.

Hywax-122 will form permanent emulsions containing as much as 90 to 95 per cent water—in neutral, acid or alkaline solutions. It forms a white, creamy lotion with no odor or separation, even after standing for weeks. With 50 per cent water, a creamy paste is formed, which may be diluted later. Hywax-122 is free of odor, light in color, heat stable—will not oxidize nor turn rancid. It is not water-soluble and 1 per cent solutions separate. Contains no ethylene oxide, polyglycols nor added emulsifiers.

Emulsifiable Hywax-122 is recommended for metal working and drawing, for chemical specialty, cosmetic and textile operations and a wide range of industrial uses, from rust inhibitors to oil well drilling. Available in plastic-lined fibre containers, tank cars or wagons. Samples, prices and technical service as requested.

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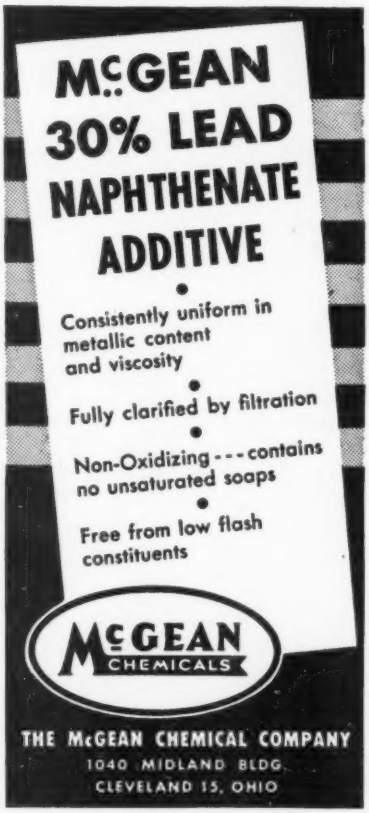

Air Force-Navy-Industry Lubricants Conference Set for November

More than 300 participants are expected to attend the unclassified Air Force-Navy-Industry Propulsion Systems Lubricants conference to be held in San Antonio, November 15 through 17, 1960.

The meeting will be sponsored by Air Research and Development Command's Wright Air Development division and Southwest Research Institute. Headquarters will be in the Hilton Hotel.

The three-day meeting will deal with both air breathing and non-air breathing systems. It will cover such topics as "Missile and Space Vehicle Lubrication Requirements," "Lubrication with Cryogenic Fluids," "Lubrication with Liquid Metals and Nonmetals," "New Development in Greases and Fluids," and "High Performance Aircraft Engine Lubrication."

Co-chairmen for the meeting are M. P. Dunnam, chief, fuel and oil branch, propulsion laboratory, WADD; and P. M. Ku, Director, aviation products and equipment research, Southwest Research Institute.

Further information may be obtained by writing P. M. Ku, Southwest Research Institute, 8500 Culebra Rd., San Antonio, Tex.

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NLGI SPOKESMAN

Panther Announces Change in Name

NLGI Active member Panther Oil & Grease Manufacturing company of Fort Worth, Texas, has changed its name to Texas Refinery corporation. Carl Shanks, first vice-president, is Company representative, while Ralph R. Uhrmacher, research director and vice-president, is Technical representative.

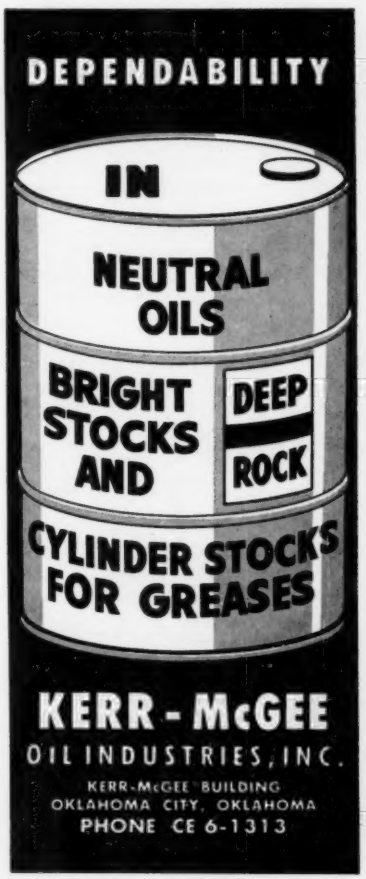
Battelle Offers Illustrated Statement

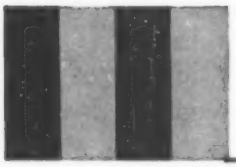
The first in a series of illustrated statements on contract research for industry has just been published by Battelle Memorial Institute, NLGI Technical Member in Columbus, Ohio. Titled "Procedures of Contract Research for Industry," this first statement serves as a point of departure for the series, which is oriented toward executives in industry who have varying degrees of decision-making responsibility for research and development programs.

"Procedures of Contract Research for Industry" describes in a step-by-step manner the relationship existing between the client and the research institute, beginning with the initial meeting of the two parties and progressing beyond the successful completion of a specific project. Phases of this relationship discussed include the preliminary conferences between the client and the research institute that precede the initiation of a research project; conferences among institute specialists to define the research objective and evaluate possible approaches; the contractural agreement between the research institute and the client; actual conduct of the research; reports to the client while the research is in progress; and the presentation of final results, as well as follow-up services provided by the institute.

In inaugurating the series, Battelle points out that while the combined facilities of the nation's contract research organizations are impressive, in actual number there are few such groups. As a result, many executives with a responsibility for managing research programs have only a limited understanding of contract research procedures. The series is an attempt to more clearly define the unique character of the contract research organization and the procedures it employs in meeting the growing demands of industry for research.

Other statements to follow in the series will cover the administrative controls of contract research by which the client maintains control of the project's objective, scope, timing, and cost, but is relieved of technological administration. The series will also include significant case histories on contract research and a discussion of the complementary relationship between the research institute and the research staff within a given industrial organization.





NLGI Associate, Technical

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Representative—Stuart L. Spradling

Ohio Farm Bureau Cooperative Association, Inc.
245 North High Street, Columbus 16, Ohio
Representative—Walter N. Callahan

Pennsylvania Refining Company
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Representative—Ben Sollitto

United Co-Operatives, Inc.
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Valvoline Oil Company
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Kolker Chemical Corporation
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Representative—Lee H. Smith

Lithium Corporation of America, Inc.
500 Fifth Ave., New York 36, N. Y.
Representative—Malcolm M. Moore

The Lubrizol Corporation
Box 3057—Euclid Station, Cleveland 17, Ohio
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Mallinckrodt Chemical Works
2nd & Mallinckrodt Sts., St. Louis 7, Mo.
Representative—D. B. Batchelor

The McGean Chemical Co.
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Metasap Chemical Division Nopco Chemical Company
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Newridge Chemical Company
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Phoenix Chemical Laboratory, Inc.
3953 Shakespeare Ave., Chicago 47, Ill.
Representative—Mrs. G. A. Krawetz

Atlantic Announces Public Relations Change

The Atlantic Refining company has announced the appointment of William G. Shain as director of public relations effective November 1, 1960. He will succeed Richard Rollins, who is retiring.

It was also announced that at that time the company's public relations function will be merged with industrial relations. The combined activities will be under the direction of H. W. Jones as vice president and general manager of industrial and public relations.

A graduate of the school of journalism of Temple university, Shain has been with Atlantic since 1946. He was appointed industrial relations manager of the company's subsidiary in Brazil in 1952 and since 1954 has headed Atlantic's foreign personnel division.

Sonneborn Bulletin Gives Formulas of Waterless Hand Cleaners

Formulations of three typical types of waterless hand cleaners and their preparation are described in a bulletin available from the Sonneborn Chemical and Refining corporation of New York.

Waterless hand cleaners, first introduced in the 1920's, were crude soap gels containing harsh abrasives and disagreeable odors. Modern variations are much improved and are finding increasing use among mechanics, painters, plumbers, electricians and even office workers. In occupations where water is limited, these cleaners also are finding ready acceptance.

According to the bulletin, the average cleaner has as its basic components a combination of detergents and petroleum solvents combined according to desired cleaning properties. The bulletin breaks down the formulations of two gel-type, and one lotion-type waterless hand cleaner into basic components. Variations on these formulas, says the bulletin, may enable a manufacturer to get exactly the type of cleaning action he wants.

The bulletin, Current Topics No. 146, may be obtained free of charge, from the department of industrial research, Sonneborn Chemical and Refining Corp., 300 Park Ave. South, New York 10, N. Y.

Produces 750,000 Steel Drums of Petroleum Products Annually

More than 750,000 new and reconditioned 55-gallon steel drums were used by Gulf Oil corporation last year to package and ship in the United States and abroad some 250 different, specially-compounded petroleum products. If laid end to end these drums would stretch from Pittsburgh to Chicago.

Company packaging officials report that substantial gains in the Corporation's world-wide operations, as reflected by a 168 per cent gain in crude oil production since 1950, made 1959 a peak year for packaging requirements. Further gains anticipated should mean even higher drum requirements for 1960.

Last year Gulf's four packaging plants at Port Arthur, Texas; Charleston, South Carolina; McKees Rocks and Philadelphia, Pennsylvania, used nearly 227,000 new drums and over 531,000 reconditioned drums.

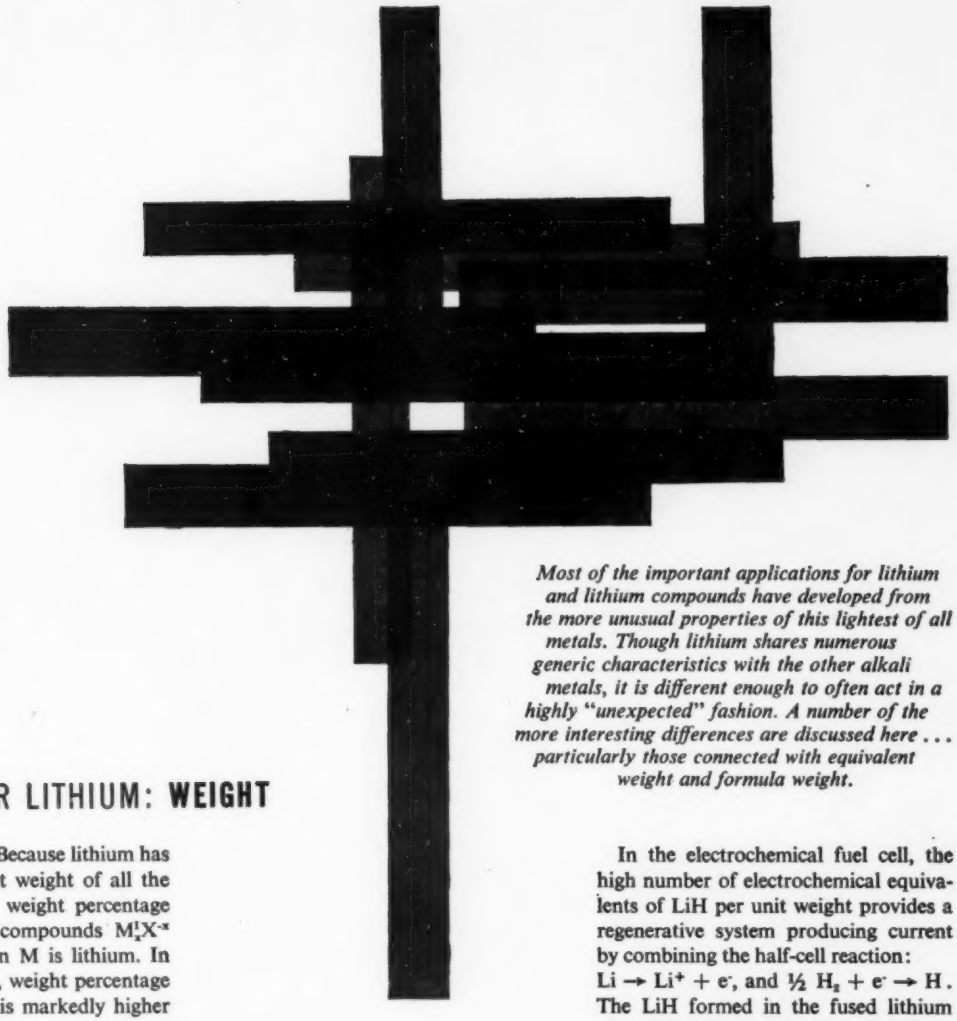
In addition to the usual shipping methods—barge, boxcar and ocean-going vessel—some Gulf drums even traveled by air on occasion to meet rush shipping schedules.

To keep transportation costs down and delivery to customers swift, Gulf products are blended from base oils and packaged at its four key points. At these quality-controlled plants, the base oils are combined with some of the several hundred chemical agents (additives) used by the Company to give each product its special ability to do a given job. These additives provide foam resistance, prevent rust formation, counteract acids and carry out dozens of additional assignments.

Gulf officials estimate that used drums can be reconditioned four to eight times depending on how hard they are used. In gentle service, the brightly painted Gulf ambassadors might successfully make the rounds 25 or more times.

NLGI GLOSSARY

Copies of the NLGI GLOSSARY . . . Definitions of Terms Relating to the Lubricating Grease Industry . . . may be purchased from the NLGI national office, 4638 J. C. Nichols Parkway, Kansas City 12, Missouri, U.S.A. NLGI members may purchase them for 15¢ per copy . . . non-members for 25¢.



Most of the important applications for lithium and lithium compounds have developed from the more unusual properties of this lightest of all metals. Though lithium shares numerous generic characteristics with the other alkali metals, it is different enough to often act in a highly "unexpected" fashion. A number of the more interesting differences are discussed here . . . particularly those connected with equivalent weight and formula weight.

THE CASE FOR LITHIUM: **WEIGHT**

EQUIVALENT WEIGHT Because lithium has the lowest equivalent weight of all the alkali metals (6.94), weight percentage of the anion X^{-x} in compounds $M^{+}_{x}X^{-x}$ will be greatest when M is lithium. In $MC1O_4$, for example, weight percentage of available oxygen is markedly higher in *lithium* perchlorate . . . to the extent that on a volume basis, there is 29% more oxygen in lithium perchlorate at room temperature than in liquid oxygen at its boiling point.

Similarly, lithium hydride provides the highest content of available hydrogen (chemical reaction equivalents or gas) . . . lithium hypochlorite the highest content of active chlorine . . . and lithium nitrite the highest nitrogen content per unit weight of reaction mixture: $(MNO_2 + NH_4Cl \rightarrow 2H_2O + N_2 + MCl)$.

WEIGHT PERCENTAGE OF AVAILABLE OXYGEN

M	$MClO_4$	MNO_2
Li	60.1	58.0
Na	52.0	47.1
K	46.2	39.6
Rb	34.6	27.3
Cs	27.5	20.5

The relatively large number of moles of material per unit weight makes lithium salts ideal fluxes or liquid formers, and freezing point depressants. This can prove of considerable consequence in reactions facilitated by a liquid phase through which reactants can readily diffuse. Relatively small quantities of lithium salts added to high temperature electrochemical processes can depress freezing points, increase fluidity, decrease viscosity and, at the same time, increase electrical conductivity.

FORMULA WEIGHT Lithium hydride's low formula weight makes it ideal for two interesting applications . . . a heat sink and an electrochemical fuel cell. In the heat sink, the high heat of fusion of LiH per unit weight provides a thermal energy source in the conversion of thermal to electrical or mechanical energy.

In the electrochemical fuel cell, the high number of electrochemical equivalents of LiH per unit weight provides a regenerative system producing current by combining the half-cell reaction: $Li \rightarrow Li^{+} + e^{-}$, and $\frac{1}{2} H_2 + e^{-} \rightarrow H^{-}$. The LiH formed in the fused lithium salt electrolyte of the cell is then thermally decomposed by a nuclear reactor to regenerate the reactants.

MORE TO COME The tale of lithium is neither quickly nor easily told. The material presented here constitutes the briefest of introductions. But if it has whet your appetite we can happily provide you with a great deal more of the same . . . long on facts and ideas, short on flim-flam, and complete with derivations and references. Just write for a copy of "Lithium vs. The Other Alkali Metals". Foote Mineral Company, 402 18 West Chelten Building, Phila. 44, Pa.

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